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C. F. MARVIN, Chief

THE OHIO AND MISSISSIPPI FLOODS OF 1912

BULLETIN Y

BY

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Professor of Meteorology

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UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU, OFFICE OF THE CHIEF,
Washington, D. C., October 2, 1913.

The honorable the SECRETARY OF AGRICULTURE.

SIR: I have the honor to transmit herewith a report on the Ohio and Mississippi floods of 1912, prepared by H. C. Frankenfield, professor of meteorology, United States Weather Bureau.

I recommend the publication of this report as a bulletin of the Weather Bureau.

Very respectfully,

C. F. MARVIN, *Chief of Bureau.*

Approved.

B. T. GALLOWAY, *Acting Secretary.*

LIST OF ILLUSTRATIONS.

CHARTS.

DIAGRAMS.

TABLE OF CONTENTS.

ERRATA.

Delete the words "Part I" on all of the charts and diagrams accompanying this paper.

THE OHIO AND MISSISSIPPI FLOODS OF 1912.

By H. C. Frankenfield, *Professor of Meteorology.*

The Drainage Basin of the Mississippi River.

A full description of the character and extent of the basin of the Mississippi River will be found in Bulletin E (Weather Bureau, 1897) and in the Annual Report of the Chief of the Weather Bureau, 1896–7, and those who desire more detailed information are referred to these publications. From them it is learned that the great drainage basin of the Mississippi River comprises an area of about 1,240,050 square miles, or about 41 per cent of the total area of the United States, exclusive of Alaska, and extending between the Allegheny and the Rocky Mountains through 56° of longitude and 21° of latitude. There are six grand subdivisions, five of them comprising the watersheds of the largest tributaries, and the names and areas of the six subdivisions are as follows (see chart 1, appendix):

Table I.

Designation.	Area in square miles.	Ratio to whole basin.
Ohio Basin	201, 700	0. 16
Upper Mississippi Basin	165, 900	. 13
Missouri Basin	527, 150	. 43
Arkansas Basin	186, 300	. 15
Red Basin	90, 000	. 07
Central Valley	69, 000	. 06
Total	1, 240, 050	1. 00

Flood Frequency.

In the Ohio River and in the Mississippi River below Cairo, Ill., years without floods are exceptional, while in the Mississippi River above Cairo stages above the flood line, as measured by the gage heights at St. Louis, Mo., are the exception rather than the rule, occurring on an average about one year in every four or five. Prior to the nineteenth century little is known of the occurrence of floods except through more or less authentic tradition. Of the lower Mississippi floods, the most notable occurred in 1815, 1828, 1844, 1849, 1850, 1851, 1858, 1859, 1862, 1865, 1867, 1874, 1882, 1884, 1890, 1893, 1897, 1903, and 1912, being 19 years in all, or an average of one flood to about each six years. In the upper Mississippi River the years of marked high water, as measured on the St. Louis gage, were 1785, 1811, 1823, 1826, 1844, 1851, 1855, 1858, 1862, 1881, 1883, 1892, 1903, and 1909, being 14 in all, or an average of one flood to about each nine years. The greatest lower Mississippi flood, measured by the flood height, occurred in 1912, while in the upper Mississippi the greatest flood was probably that of 1785, "L'annee des grandes eaux," when the river at St. Louis is said to have reached a stage corresponding to a height of 42 feet on the present gage, or 0.6 foot higher than the stage of June 28, 1844. However, the stage of 42 feet in 1785 is not one of actual record, but of tradition only, and the flood of 1844 is usually considered to have been the greatest of upper Mississippi and lower Missouri floods.

Causes of Mississippi River Floods.

The normal rains of late winter and early spring over the lower Mississippi Valley are usually sufficient to bring the rivers almost to the flood stage from Cairo to the Gulf of Mexico. Then, if the spring rains over the Ohio Basin are heavier than usual, an enormous volume of water from the main river and the swift-running mountain tributaries is brought down upon the lower Mississippi, already at bank-full stage, and a disastrous flood results. If the winter happened to be a moderately cold one, with plenty of snow laying upon the ground, there would be a further increment from the melted snows, as the spring rains are almost invariably accompanied by high temperatures. Thus the Ohio and the lower Mississippi Rivers alone can produce a great flood, independently of the upper Mississippi and the great western tributaries of the lower river. The upper Mississippi, while in itself incapable of causing a flood in the lower river, yet, rising later than the Ohio, as a rule, serves to prolong the high water and at times to increase somewhat the stages from Cairo southward. Fortunately the lower western tributaries thus far do not appear to have played an important part in flood causation, yet the possibility of simultaneous floods in both the eastern and the western tributaries and in the main stream is ever present; and should this condition arise, the resulting stages between Cairo and the Gulf would probably be higher than have yet been recorded.

It appears that the precipitation that directly causes the Ohio and Mississippi floods is due to a single type of storm known as "The Southwest" type, for the reason that usually it is first observed in definite formation over the southwestern portion of the country. These storms move in from the Pacific Ocean, the majority of them by way of the north coast, whence they move southeastward through the great plateau until they reach western Texas, when they turn northeastward over the Ohio Valley and the Lake region with increased development and velocity of movement, accompanied by heavy rains and high temperatures over the Gulf States and the Ohio Valley, and frequently by snow to the northward. A small portion moves inland by way of California, and a still smaller portion by way of Mexico, but, with rare exceptions, all reach Texas and move northeastward as indicated above. None appears to develop true storm conditions until Texas is reached, and about 95 per cent of them are preceded and accompanied by heavy rains and high temperatures to the eastward and southeastward, and by rains and snows to the northward. If the temperatures to the northward range between 25 and 32° F. the snowfall will be heavy, both as to quantity and character. Flood probability depends upon the number and time of occurrence of these southwest storms, and, of course, somewhat upon the antecedent conditions. The storms usually begin in February and continue during March and at times a portion of April. If the early winter has been a cold one, resulting in a frozen soil and the accumulation of a considerable amount of snow over the Ohio watershed, the flood probability will be increased. If there should be but a single storm, or even if there should be several storms separated by considerable intervals of time, the flood wave will be short and the river stages only moderately high, but if there should be a series of storms, separated by intervals of only a few days, as in the present year, a severe flood is certain, and its intensity will be limited only by the amount of precipitation, which in any event is almost certain to be heavy. The accumulated snowfall will usually go out with the first storm, and, if the early winter has been cold, the run-off from the first one or two storms will obviously be greater than the normal run-off. The normal winter and spring rainfall over the Gulf States is comparatively heavy and any considerable increase in the amount, if distributed over an extended period of time, will bring the lower Mississippi and the Yazoo Rivers to stages above the flood line and while in this condition the extensive flood wave from the Ohio pours in, provided the direction of storm movement has been about normal. If, by any chance, the storm centers, or any number of them, should pass to the southward of the Ohio Valley, the precipitation over that district would be much less in quantity and the temperature would be much lower, thereby preventing the melting of any considerable quantity of the snow that might be on the ground. Consequently the lower Mississippi flood would pass into the Gulf of Mexico without unusual incident unless additional heavy rains should bring the western tributaries to very high stages—a comparatively infrequent occurrence and one not of any considerable moment so far as the lower river itself is concerned—as the Ohio River is the principal factor in the question.

THE FLOOD OF 1912.

The annual rise of the lower Mississippi River for the year 1912 began on February 21, at which time a severe storm from the Southwest was moving northeastward over the lower Mississippi and the Ohio Valleys, attended by general and heavy rains. A second storm of similar character moved northeastward four days later, and the rise was well under way in the lower Ohio River and in the lower Mississippi between Cairo and the mouth of the Arkansas River. By the end of February the Ohio River was above the flood stage from Evansville, Ind., to Shawneetown, Ill., while the Mississippi was rising rapidly as far south as the mouth of the Red River, and had nearly reached the flood stage of 34 feet at New Madrid, Mo. The winter had been a cold one, without much snow over that portion of the Ohio watershed where it would have remained on the ground for any considerable period after it had fallen, and it so happened that on February 26 there was no accumulated snowfall over any portion of the Ohio River watershed except a negligible quantity over central and southern Indiana and southeastern Illinois. There were no heavy rainstorms probable in the near future, and consequently no immediate fears of a great flood. While rains and snows were comparatively frequent during the first decade of March, they were not heavy, and after March 4 the Ohio River at Cairo began to fall after reaching a stage of 41.8 feet, 3.2 feet below the flood stage. Shortly afterwards the Mississippi River began to fall at New Madrid and the fall continued for about 10 days, but did not extend below the mouth of the Arkansas River, as the occasional rains were sufficient to maintain the original rise from above. On March 10 an extensive barometric depression moved in from the Pacific Ocean to southern California, and by the following morning it had reached Kansas, with a secondary storm center reaching down over southeastern Texas. During the day (March 11) the general disturbance moved eastward and northeastward over the normal path of southwestern storms, and moderately heavy rains, averaging less than 1.5 inch, fell over Louisiana and Mississippi. Over the Ohio Basin the rains, while well distributed, were not heavy, and some light snow fell, the quantity being just about sufficient to maintain the average depth of from 1 to 3 inches that had covered that portion of the Ohio watershed north of Tennessee since the earliest days of March. While this storm was moving across the country another appeared on the north Pacific coast. It moved southeastward over the districts west of the Rocky Mountains, and by the time (March 14) that the preceding storm had passed off the Newfoundland coast, the second one had moved to Kansas, accompanied, like its immediate predecessor, by a secondary depression extending southward over southeastern Texas. During the succeeding 24 hours rains again fell over Louisiana and Mississippi and extended into the lower Ohio Valley, with lighter rains above. The heaviest rains fell over the Yazoo Valley, but the quantity was not excessive. The rains did not continue for more than 24 hours, as a rule, but they were sufficient to take out the little snow that covered the Ohio watershed and to augment a rise in the upper Ohio River that had set in after the rains from the preceding storm, and also to start another rise in the lower Ohio and in the Mississippi from Cairo to New Madrid. At the same time the Missouri River east of Kansas City and the Mississippi from Alton, Ill., to Cairo began to rise. This second storm passed into the north Atlantic Ocean during the night of March 15–16, and during the next four days there was no precipitation of consequence over the Ohio and lower Mississippi watersheds. On the morning of March 19 a disturbance was central over Utah, and at this time some of the river stages were as follows:

TABLE 11.—*River stages, Mar. 19, 1912.*

Station.	River.	Flood stage.	Stage, Mar. 19.
		Feet.	*Feet.*
Cincinnati, Ohio	Ohio	50	46.6
Evansville, Ind	do	35	37.2
Nashville, Tenn	Cumberland	40	37.9
Johnsonville, Tenn	Tennessee	25	26.8
Paducah, Ky	Ohio	43	36.1
Cairo, Ill	do	45	40.4
Kansas City, Mo	Missouri	22	8.9
Hannibal, Mo	Mississippi	13	6.2
St. Louis, Mo	do	30	18.7
New Madrid, Mo	do	34	31.6
Memphis, Tenn	do	33	29.2
Helena, Ark	do	42	37.4

At Helena the second rise of the month was just about to begin.

The Utah depression, the third storm of the month, moved over the Ohio Valley by way of Oklahoma and Arkansas, somewhat to the northward of its immediate predecessors, with moderate rains and snows above Cairo, but with little or none below. The precipitation from this storm apparently had no effect other than to check the decline in the upper Ohio River, and the storm center passed into the north Atlantic Ocean during the night of March 21–22. However, another storm had appeared over Arizona, and an offshoot from it traversed the usual path over Texas, reaching the Ohio Valley on the morning of March 24, when the Missouri River east of Kansas City, the Mississippi from Alton to New Orleans, and the Ohio, Cumberland, Tennessee, and Wabash Rivers were rising steadily. The rainfall resulting from this fourth storm was the heaviest of the month, beginning on March 22 over Louisiana and southern Mississippi and extending northward and eastward during the two following days with an average fall of 2.5 inches over the lower Mississippi Valley and somewhat less over the Ohio Valley. At the same time a heavy blanket of moist snow was deposited over Missouri and Kansas, with an average water equivalent of over 1 inch. There was also some snow, probably sufficient to make one-half inch of water, over the northern portion of the Ohio River watershed. As the soil was deeply frozen after the long and cold winter, this large snowfall was equivalent to another heavy rain, and it must necessarily run into the rivers as soon as the temperatures rose to normal conditions or another rainstorm came. Should the high temperatures and the rain come coincidently, as they do during southwestern storms, conditions would become still more threatening. There were no longer any doubts that a severe flood would occur. The only question was as to the final outcome which was now entirely dependent upon the contingency of additional heavy rains in the near future. If there should be more the flood height must certainly prove to be the greatest of record from Cairo to the Passes should the levees remain intact.

The suspense was not prolonged, for on March 26, one day after the fourth storm moved into the Atlantic Ocean, the fifth one appeared over Nevada. The river stages at various places and the changes in one week from Helena northward, due to the third and fourth storms, were as follows:

TABLE III.—*River stages, Mar. 26, 1912.*

Station.	River.	Flood stage.	Stage Mar. 26.	Change one week.
		Feet.	*Feet.*	*Feet.*
Cincinnati, Ohio	Ohio	50	52.2	+ 5.6
Evansville, Ind	do	35	41.0	+ 3.8
Nashville, Tenn	Cumberland	40	27.6	−10.3
Johnsonville, Tenn	Tennessee	25	29.2	+ 2.4
Paducah, Ky	Ohio	43	43.3	+ 7.2
Cairo, Ill	do	45	49.2	+ 8.8
Kansas City, Mo	Missouri	22	13.8	+ 4.9
Hannibal, Mo	Mississippi	13	10.0	+ 3.8
St. Louis, Mo	do	30	24.7	+ 6.0
New Madrid, Mo	do	34	38.8	+ 7.2
Memphis, Tenn	do	33	35.3	+ 6.1
Helena, Ark	do	42	42.0	+ 4.6
Little Rock, Ark	Arkansas	23	14.0	+ 1.4
Arkansas City, Ark	Mississippi	47	45.5	+ 1.3
Yazoo City, Miss	Yazoo	25	23.8	+ 1.0
Vicksburg, Miss	Mississippi	45	43.0	+ 1.1
Natchez, Miss	do	46	42.6	+ 1.5
Alexandria, La	Red	36	22.7	+ 0.1
Baton Rouge, La	Mississippi	35	31.3	+ 1.0
Donaldsonville, La	do	28	24.7	+ 0.8
New Orleans, La	do	18	15.4	+ 0.2
Monroe, La	Ouachita	40	35.9	+ 4.4
Simmesport, La	Atchafalaya	41	36.0	+ 1.7
Melville, La	do	37	36.1	+ 1.2

Owing to stagnant pressure conditions in the extreme West, the fifth storm did not reach Texas until the morning of March 28, when rains were falling over the great central valleys. Approximately 1 inch of rain fell, with the greatest fall below Cairo; and the storm also melted and brought out the heavy, moist snow that had fallen during the preceding storm, so that the run-off was practically doubled. It was now certain that, should the levees hold, all previous high-water records from Cairo to Memphis would be exceeded, and equally certain that another heavy rain would result in similar conditions from Memphis south to the mouth of the river. Again the period of suspense was short, for on the evening of March 29 another disturbance, the sixth and last of the remarkable series, was central over Utah. It moved more slowly than its predecessors and did not reach eastern Texas until the morning of April 1, moving then to the northeastward over the Ohio Valley. It happened, unfortunately, that the rains from this storm were heaviest over those sections where they were least desired. Over Louisiana and southern Mississippi, where another inch or so of rain would not have changed conditions materially, the rainfall was light, while to the northward almost as far as St. Louis and to the eastward over Tennessee and Kentucky it was heavy, especially over eastern Arkansas and the Yazoo Valley. As a result the rate of rise in the lower Ohio and the lower Mississippi was maintained or increased, the Cumberland passed the flood stage, the Tennessee rose more rapidly, while the Missouri east of Kansas City, the Mississippi from Hannibal to Cairo, the lower Arkansas, the White and the Black Rivers also passed the flood stage. There could be no further doubt, and warnings were issued that the coming flood heights from Cairo to the

Gulf of Mexico would be the greatest in history. The stages at this time and the changes in one week were as follows:

TABLE IV.—*River stages, Apr. 2, 1912.*

Station.	River.	Flood stage.	Stage Apr. 2.	Change one week.
		Feet.	*Feet.*	*Feet.*
Cincinnati, Ohio	Ohio	50	46.8	− 5.4
Evansville, Ind	do	35	42.3	+ 1.3
Nashville, Tenn	Cumberland	40	41.8	+14.2
Johnsonville, Tenn	Tennessee	25	31.6	+ 2.4
Paducah, Ky	Ohio	43	47.8	+ 4.5
Cairo, Ill	do	45	53.5	+ 4.3
Kansas City, Mo	Missouri	22	23.1	+ 9.3
Hannibal, Mo	Mississippi	13	14.8	+ 4.8
St. Louis, Mo	do	30	29.8	+ 5.1
New Madrid, Mo	do	34	42.3	+ 3.5
Memphis, Tenn	do	33	41.9	+ 6.6
Helena, Ark	do	42	48.9	+ 6.9
Little Rock, Ark	Arkansas	23	21.4	+ 7.4
Arkansas City, Ark	Mississippi	47	50.2	+ 4.7
Yazoo City, Miss	Yazoo	25	25.3	+ 1.5
Vicksburg, Miss	Mississippi	45	46.1	+ 3.1
Natchez, Miss	do	46	44.8	+ 2.2
Alexandria, La	Red	36	29.0	+ 6.3
Baton Rouge, La	Mississippi	35	32.9	+ 1.6
Donaldsonville, La	do	28	26.0	+ 1.3
New Orleans, La	do	18	16.7	+ 1.3
Monroe, La	Ouachita	40	39.6	+ 3.7
Simmesport, La	Atchafalaya	41	38.0	+ 2.0
Melville, La	do	37	37.4	+ 1.3

The rains continued during April and May with more or less frequency, and at times they were heavy, but they do not appear to have done more in the main stream than to prolong the high-water period, as in most instances the loss of water through the crevasses more than offset the effects of the rains. An exception was noted at New Orleans, where during the evening of May 10 nearly 7 inches of rain fell, forcing the river up to the remarkably high stage of 22 feet, or 4 feet above the flood stage, a few hours later. High southerly winds, however, were an important factor in causing this stage, and a decline to the actual high-water level followed shortly afterwards.

Among the appendices to this report will be found copies of the United States Weather Bureau charts (Nos. 2 to 7, inclusive) showing the storms directly contributory to the flood, and also copies of the Weekly Snow Charts (Nos. 8 to 11, inclusive) showing the depth of snow on the ground at different times during the flood.

DURATION OF THE FLOOD.

As the Ohio River at Evansville, Ind., reached the flood stage of 35 feet on March 18, the flood may be considered to have begun on that day. The Mississippi River at New Orleans, La., fell below the flood stage of 18 feet on June 8, and this day may be considered to have been the last day. This would make the total duration of the flood 83 days. In the Atchafalaya River the flood lasted until June 19, on which day the river at Melville, La., fell below the flood stage of 37 feet. Flood stages in this river, however, were not recorded until April 9, when the stage of 41 feet was first reached at Simmesport, La., making the flood duration 72 days. The Yazoo River was in flood for 75 days, beginning on April 1 and ending June 14, while the lower Ouachita River was in flood for 62 days, beginning on April 4 and ending on June 4 at Monroe, La.

The first rise began on February 21 with the advent of a typical southwestern storm, but early in March it was followed by a decline that continued for a week or 10 days as far south as Helena, Ark. Below the mouth of the Arkansas River the initial rise was practically uninterrupted. The duration of the flood was materially increased by some abnormally heavy rains that fell over the entire watershed east of Kansas City during the last few days of April. These rains sent a second flood wave down the river, with resulting secondary crests only 0.5 foot below the original one at St. Louis, but 5 to 6 feet lower from Cairo to the mouth of the St. Francis River. From Helena southward the effects consisted only of a considerable prolongation of the original flood wave. The hydrographs (Diagram III, appendix) show the actual conditions that prevailed from March 1 to June 10, inclusive. Hydrographs of the floods of 1882, 1897, and 1903 are also shown. (Diagrams IV, V, and VI.) From these hydrographs it will be seen that the Ohio River at Cincinnati developed two distinct major crests, one on March 27, when the stage was 53.4 feet, and another on April 5 and 6, when the stage was 51.7 feet. There was also a minor crest of 36.7 feet on April 30 following a decline to 21.9 feet on April 26. In all, the Ohio River at Cincinnati was above the flood stage of 50 feet on 10 days.

There were two crests in the Mississippi River at St. Louis, one of 30.8 feet on April 5, and another of 30.3 feet on April 30, the latter resulting from the heavy rains of April 25 and 26. The river was above the flood stage of 30 feet on 10 days. At Cairo the Ohio River first reached the flood stage of 45 feet on March 22, and from that time until the end of the flood there were two crests, one of 54 feet on April 6 and 7, and another of 49.3 feet on May 4 and 5. The stage of 54 feet on April 6 and 7 was 1.8 feet higher than the previous high-water record of February 27, 1883, and only the failure of the levees in the immediate vicinity and below prevented a crest stage of at least 55 and possibly 56 feet, the latter stage representing the maximum capacity of the Cairo City Levee. Flood stages prevailed for 45 days in all.

At Memphis there were also two crests, corresponding with the conditions at Cairo. The river first reached the flood stage of 33 feet on March 24, and did not fall below it for 60 days. The great crest occurred on April 6, when the stage was 45.3 feet, 5 feet above the previous high-water mark of February 3, 1907; and here again the failure of the levees prevented a stage of at least 47 feet, or nearly 7 feet higher than the stage of 1907. The second crest of 38.9 feet occurred on May 10.

At Helena the flood stage of 42 feet was passed on March 26, and a stage below 42 feet was not again reached until May 26, making a total of 62 days that the river was above the flood stage. The highest stage occurred on April 21, and was 54.4 feet, 2.6 feet above the previous high-water record of April 4, 1897. There was but one crest after the great rise set in.

At Vicksburg the flood stage of 45 feet was reached on March 31, and the river was at or above the flood stage until May 31, a period of 62 days. There were two crests; one a principal one of 52.1 feet on April 12, and a secondary one of 48.4 feet on May 6 and 7. Heavy rains over the Yazoo watershed were responsible for the second crest. The high stage of 52.1 feet was 0.4 foot lower than the record stage of April 16, 1897, the Panther Forest and Salem crevasses being responsible for the deficiency in 1912. Had these levees remained intact, the crest stage at Vicksburg would have been 53.5 feet or 54 feet, and, if only one of the two levees had held, it is very probable that the high-water mark of 1897 would have been exceeded somewhat.

At New Orleans the river was above the flood stage of 18 feet from April 10 to June 8, inclusive, a period of 60 days. There was a single crest of 22 feet in the early morning of May 11. This was 1.6 feet above the previous high-water record of April 6 and 7, 1903, and was partially due to an unfortunate combination of high southerly winds and torrential local rains. Conditions above New Orleans had indicated a maximum stage of 21.5 feet, which was the stage actually reached after the effects of the high winds and local rains had disappeared a few hours later.

Records were also exceeded in the Atchafalaya River, the excess ranging from 2.2 to 2.8 feet. The Ouachita River failed by nearly 3 feet to equal the record of 1874.

FLOOD STAGES, 1912—COMPARATIVE DATA.

Table V shows the highest stages reached at various places during the flood, together with the dates thereof; also the highest recorded stages and dates at the same places previously to the flood of 1912, and the departures of the latter from the same. By flood stage is meant the stage above which damaging overflow ordinarily begins, and the data are repeated for the sake of convenience. On March 1, 1912, the flood stage at Memphis was increased from 33 to 35 feet, but for purposes of comparison the old flood stage of 33 feet has been used throughout this report.

TABLE V.—*Comparative data.*

Station.	River.		Highest stage.	1912 Date.	Highest stage.	Previous date.	1912.
		Feet.	*Feet.*		*Feet.*		*Feet.*
Cincinnati	Ohio	50	53.4	Mar. 27	71.1	Feb. 14, 1884	−17.7
Evansville	do	35	42.6	Mar. 31	48.0	Feb. 19, 1884	− 6.2
Nashville	Cumberland	40	46.5	Apr. 8	55.3	Jan. 22, 1882	− 8.8
Johnsonville	Tennessee	25	35.4	Apr. 6	48.0	Mar. 24, 1897	−12.6
Paducah	Ohio	43	49.9	Apr. 8–11	54.2	Feb. 23, 1884	− 4.3
Cairo	do	45	54.0	Apr. 6–7	52.2	Feb. 27, 1883	+ 1.8
Kansas City	Missouri	22	23.2	Apr. 17	38.0	June 20, 1844	−14.8
Hannibal	Mississippi	13	19.0	Apr. 8	22.5	June 8, 1903	− 3.5
St. Louis	do	30	30.8	Apr. 5	41.4	June 28, 1844	−10.6
New Madrid	do	34	44.0	Apr. 5–6	41.5	Feb. 24, 1884	+ 2.5
Memphis	do	33	45.3	Apr. 6	40.3	Feb. 3, 1907	+ 5.0
Helena	do	42	54.4	Apr. 12	51.8	Apr. 4, 1897	+ 2.6
Little Rock	Arkansas	23	24.0	May 4	32.6	May —, 1844	− 8.6
Arkansas City	Mississippi	47	55.4	Apr. 12	53.0	Mar. 27, 1903	+ 2.4
Yazoo City	Yazoo	25	30.4	Apr. 17	36.5	———, 1882	− 6.1
Vicksburg	Mississippi	45	52.1	Apr. 12	52.5	Apr. 16, 1897	− 0.4
Natchez	do	46	51.4	Apr. 14–17	50.4	Mar. 28, 1903	+ 1.0
Alexandria	Red	36	33.6	Apr. 22	41.8	July 6, 1908	− 8.2
Baton Rouge	Mississippi	35	43.8	May 11, 13	40.6	May 13–15, 1897	+ 3.2
Donaldsonville	do	28	34.8	May 11	32.8	May 13, 1897	+ 2.0
New Orleans	do	18	22.0	May 11	20.4	Apr. 6, 7, 1903	+ 1.6
Monroe	Ouachita	40	46.2	Apr. 22	49.1	————, 1874	− 2.9
Simmesport	Atchafalaya	41	50.1	May 11–16	47.3	May —, 1897	+ 2.8
Melville	do	37	41.9	May 6–15	39.7	June 22, 23, 1908	+ 2.2

An inspection of the above table shows that new high-water marks were established from Cairo to New Orleans, except in the vicinity of Vicksburg, where a higher stage was prevented by the crevasses at Panther Forest, Ark., and at Salem, near Lake Providence, La. Had not these crevasses occurred, or had they occurred several days later, the crest stage at Vicksburg would certainly have been at least 1 foot above the high-water mark of April 16, 1897, when the stage was 52.5 feet. The crest stage of 22 feet at New Orleans represented the maximum effect of wind and water, and was as high as it could have been under any combination of existing circumstances.

COMPARISON WITH THE FLOODS OF 1882, 1897, AND 1903.

Precipitation.—During the month of January, 1912, the precipitation was generally deficient over the Mississippi Basin except southeastern Louisiana, with the greatest deficiency, something over 2 inches, over the Cumberland and the Tennessee watersheds, and between 1 and 2 inches over the remaining areas east of Kansas City, except along the lower Ohio River, where there was a slight excess. In February there was almost a similar deficiency east of the ninety-fifth meridian, and a slight excess to the westward, while in March there was a general excess except over the Mississippi Valley above Keokuk, Iowa, and over the extreme Northwest. The excess ranged from 2 to 4 inches, and was greatest over northwestern Georgia, northern Alabama, Mississippi, southern Arkansas, and northern Louisiana, comprising principally the watersheds of the Tennessee, Yazoo, lower Mississippi, lower Arkansas, and Ouachita Rivers. For the period from January 1 to April 2, inclusive, the latter being the date of the last storm directly concerned in the flood causation, there was an excess of from 2 to 2.5 inches over the Missouri Basin east of Kansas City, and somewhat less to the northwestward; between 1 and 2 inches over the lower Ohio Basin, and generally from 2 to 2.5 inches over the remainder of the Mississippi Basin below the mouth of the Missouri River. There was, however, a deficiency, due to light January and February rains, of over 2 inches in the district extending from the extreme lower Yazoo Valley southwestward through central Louisiana, and an enormous excess over southeastern Louisiana, amounting to 5 inches at New Orleans and 10 inches at Donaldsonville, La. This excess was due to the fact that the January rains, as well as those of March, were unusually heavy.

Charts Nos. 12 to 19, inclusive (appendix), show the total and normal precipitation by months (the data for the first two days of April being incorporated with those for March), the total and normal precipitation for the entire period from January 1 to April 2, inclusive, and the departures from the normals for each month and for the entire period.

Preceding and during the flood of 1882 there was an excess of from 1 to 8 inches of precipitation above Cairo, except in the Missouri Valley, and from 8 to 12 inches below. There was a great excess (3 to 11 inches) below Cairo in January, and a comparatively small one above, while in February there was a general excess east of Kansas City, ranging from 1 to 7 inches, with the maximum over southern Illinois, southeastern Missouri, and Arkansas. During March the precipitation was nearly normal above Cairo, and from 2 to 4 inches in excess below. The flood of 1882, however, was a February flood, and the precipitation of March was not of material consequence.

Charts Nos. 20 to 26, inclusive (appendix), show the total and normal precipitation for January, February, and March, 1882, the total and normal precipitation for January and February combined, the departures from the normals for January and February, and for the two months combined.

In 1897 the precipitation was much less than in 1882. There was an excess in January over the lower Missouri and the Arkansas Basins and in the Central Valley, which brought on the normal winter rise. During February the precipitation was moderate, and really deficient, except over the upper Ohio watershed, but much of that over the Ohio Basin occurred within a short period of time, and started the flood. During March there was a general excess east of Kansas City, ranging, as a rule, from 2 to 4 inches above Cairo, and from 4 to 6 inches below. Roughly speaking, the excess in 1897 was only about one-half that of 1882, with the rapidity of fall as the balancing factor.

Charts Nos. 27 to 32, inclusive (appendix), show the normal precipitation and the actual conditions that occurred.

The precipitation that caused the flood of 1903 did not differ greatly in amount from that of 1897, although there was great difference in its distribution. In 1903 the excess above Cairo was only about one-half as large as in 1897, while below Cairo it was nearly double, the heaviest rains falling during February below Cairo, and during March above.

The charts Nos. 33 to 35, inclusive (appendix), show the actual and normal precipitation for January, February, and March, 1903.

A comparison of the precipitation charts discloses the fact that the precipitation preceding and during the flood of 1882 was much greater than that of the three other floods. That of 1897 was somewhat, although not decidedly, greater than that of 1903, and also somewhat greater than that of 1912, while that of 1903 was the least of all. So that measured by the amount of precipitation, the relative order of the four great floods was as follows: 1882, 1897, 1912, and 1903. These data, while of some interest, are not of great importance, as the rate of fall and the interval between rainstorms, as well as the character of the seasons, are the natural controlling factors.

Comparative stages.—The table immediately following shows the highest stages reached at various stations during the floods of 1882, 1897, 1903, and 1912, the highest stage at each station during the four floods being in italics. No reference is made to dates, and the table is inserted merely to display comparative data in convenient form.

Diagrams Nos. I and II (appendix), also show the same data in another form, but for a limited number of stations only.

TABLE No. VI. *Highest river stages at various places during the floods of 1882, 1897, 1903, 1912, and 1913.*[1]

Station.	River.	Highest stage (feet).				
		1882	1897	1903	1912	1913[1]
Cincinnati, Ohio	Ohio	58.6	61.1	53.2	53.4	*70.0*
Evansville, Ind	...do	44.9	43.6	42.4	42.6	*48.4*
Nashville, Tenn	Cumberland	*55.1*	48.7	40.7	46.5	44.9
Johnsonville, Tenn	Tennessee	43.8	*48.0*	33.7	35.4	33.3
Paducah, Ky	Ohio	49.9	50.9	47.6	49.9	*54.3*
Cairo, Ill	...do	51.8	51.6	50.6	54.0	*54.8*
Kansas City, Mo	Missouri		22.8	[2] *35.0*	23.2	21.9
Hannibal, Mo	Mississippi	7.0	20.8	[2] *22.5*	19.0	14.3
St. Louis, Mo	...do	28.2	31.0	[2] *38.0*	30.8	27.2
New Madrid, Mo	...do			39.5	44.0	*44.5*
Memphis, Tenn	...do	35.0	37.1	40.1	45.3	*46.5*
Helena, Ark	...do	47.2	51.8	51.0	54.4	*55.2*
Little Rock, Ark	Arkansas	*25.7*	21.4	24.8	24.0	17.3
Arkansas City, Ark	Mississippi		51.9	53.0	*55.4*	55.1
Yazoo City, Miss	Yazoo		*31.5*	28.7	30.4	29.8
Vicksburg, Miss	Mississippi	48.8	*52.5*	51.8	52.1	52.3
Natchez, Miss	...do		49.8	50.4	51.4	*52.4*
Alexandria, La	Red	34.8	26.3	*36.2*	33.6	24.2
Baton Rouge, La	Mississippi		40.6	40.0	*43.8*	41.3
Donaldsonville, La	...do		32.8	32.2	*34.8*	32.7
New Orleans, La	...do	15.8	19.5	20.4	*22.0*	20.5
Monroe, La	Ouachita		37.9	44.5	*46.2*	36.9
Simmesport, La	Atchafalaya				*50.1*	46.9
Melville, La	...do		36.1	38.7	*41.9*	41.7

[1] Supplied in 1913. [2] Occurred later than the lower Mississippi flood.

An inspection of the above table shows clearly that there has been a steady increase in the flood heights below Cairo without a corresponding increase in the quantity of precipitation. While the highest stages occurred in 1912, the greatest precipitation occurred in 1882, and while there were no marked differences in the quantity of precipitation in 1897 and 1903, yet the stages in the latter year were considerably higher, except in certain localities where levee crevasses in 1903 were followed by some depression in the flood plane. This absence of the natural relation between volume and stage is, of course, due to some cause other than differences in the quantity of precipitation, and that cause is the influence of the levees which have gradually been extended until the entire river has been practically canalized between Cairo and the Passes. It should be stated, however, that the flood of 1912 occurred later in the season than usual, permitting the northern and western flood waters to meet and combine with those from the eastern tributaries, and thereby to increase somewhat the stages from Cairo southward.

Just what effect the upper Mississippi stages had upon the stage at Cairo can not now be stated with precision. However, the crest stage of 49.9 feet at Paducah, Ky., in 1912 indicated some disturbance of the normal gage relations between that place and Cairo, the stage of 54 feet at the latter place having been somewhat too high. In 1882 with about the same general conditions over the Ohio watershed above Cairo (Cincinnati about 5 feet higher than in 1912, but with the Cumberland and Tennessee in moderate flood only) the crest stage at Paducah was 50 feet, almost exactly the same as in 1912. In 1882 the crest stage at Cairo was 51.9 feet, with 28.2 feet at St. Louis, whereas in 1912 the crest stage at Cairo was 54 feet (and would have been at least 55 feet had the levees held), while the stage at St. Louis was 30.8 feet, or 2.6 feet higher than in 1882. How much of this 2.1 or possibly 3.1 feet of excess at Cairo came from the excess of 2.6 feet at St. Louis, and how much was due to the extension of the levee system, the writer is unable to state.

Table VII shows in another form the progressive influence of levee construction upon the gage relations between Cairo and Helena.

TABLE VII.—*Gage relations between Cairo and New Madrid, Memphis and Helena.*

Year.	Cairo stage.	Number of feet above or below Cairo stage.		
		New Madrid.	Memphis.	Helena.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1882	51.8	....	−16.8	−4.6
1897	51.6	....	−14.5	+ .2
1903	50.6	−11.1	−10.5	+ .4
1912	54.0	−10.0	− 8.7	+ .4

The effects of levee crevasses were less noticeable at Memphis than at New Madrid or Helena, and the figures show that with an open river, as in 1882, the difference between the Cairo and Memphis stages was nearly 17 feet, whereas at the present time with a closed river it is only about 9 feet, indicating a rise of 8 feet at Memphis due to the building of levees. As the levee system is now practically complete, so far as linear extent is concerned, this difference of about 8 feet will probably stand for the future, it being assumed that the losses through crevasse effect during the flood of 1912 were about the same at Cairo as at Memphis.

Comparative duration.—Table No. VIII shows the number of days the rivers at various places were at or above the flood stage and the number of days they were 5 feet or more above the flood stage during the floods of 1882, 1897, 1903, and 1912.

TABLE VIII.

Station.	River.	Flood stage.	Number of days river was at or above flood stage.				Number of days river was 5 feet or more above flood stage.			
			1882	1897	1903	1912	1882	1897	1903	1912
		Feet.								
Cincinnati, Ohio	Ohio	50	9	7	8	10	3	6	0	0
Evansville, Ind	do	35	60	33	45	31	20	24	18	21
Nashville, Tenn	Cumberland	40	30	16	1	16	24	6	0	8
Johnsonville, Tenn	Tennessee	25	......	40	18	30	......	30	11	12
Paducah, Ky	Ohio	43	59	32	14	23	10	13	0	13
Cairo, Ill	do	45	56	48	25	45	10	19	8	22
Kansas City, Mo	Missouri	22	0	6	0	8	0	0	0	0
Hannibal, Mo	Mississippi	13	0	46	0	17	0	7	0	4
St. Louis, Mo	do	30	0	5	0	10	0	0	0	0
New Madrid, Mo	do	34	......	54	53	57	......	19	8	25
Memphis, Tenn	do	33	65	53	54	60	0	0	13	37
Helena, Ark	do	42	79	61	67	62	5	35	22	50
Little Rock, Ark	Arkansas	23	6	0	2	4	0	0	0	0
Arkansas City, Ark	Mississippi	47	2	50	42	61	0	0	13	26
Yazoo City, Miss	Yazoo	25	......	71	47	75	......	34	0	23
Vicksburg, Miss	Mississippi	45	39	70	59	62	0	37	21	11
Natchez, Miss	do	46	29	62	54	63	0	0	0	8
Alexandria, La	Red	36	......	0	7	0	......	0	0	0
Baton Rouge, La	Mississippi	35	28	64	65	69	0	18	5	18
Donaldsonville, La	do	28	......	67	66	66	......	0	0	23
New Orleans, La	do	18	0	52	62	60	0	0	0	0
Monroe, La	Ouachita	40	......	0	38	62	......	0	0	33
Simmesport, La	Atchafalaya	41	......	......	......	69	......	......	......	43
Melville, La	do	37	......	0	45	81	......	0	0	0

It is rather difficult to decide from the above figures as to the relative importance of these four floods, but it appears that, measured by volume of water, the flood of 1882 was the greatest. It is true that the confinement of the waters between the levees in 1897, 1903, and 1912 resulted in a greater velocity of stream flow and consequent shortening of the flood period, but this condition was probably modified considerably by the return of the overflow and crevasse water which would operate to prolong the flood period. It is noted, however, that the extreme flood heights were more prolonged in 1912 than in 1882, 1897, or 1903, due both to levee effect and to the slow return of the overflow and crevasse water. The general superiority of the flood of 1897 over that of 1903 is also indicated, as well as the inferiority of the former to those of 1882 and 1912.

Relative importance of the four floods—Final conclusions.—If the estimates of the relative importance of the floods of 1882, 1897, 1903, and 1912, as stated in the foregoing, are accepted as correct, the general conclusions may be summarized as follows:

TABLE IX.—*Relative importance of the floods of 1882, 1897, 1903, and 1912.*

As to	Relative order.			
	First.	Second.	Third.	Fourth.
Precipitation	1882	1897	1912	1903
Stage	1912	1903	1897	1882
Duration	1912	1882	1897	1903
As a whole	1912	1897	1903	1882

The maximum stage is of course the principal factor, the one that governs in any discussion of the problem. It is the basis of comparison for the past and of estimates for the future, and all measures that may be devised for absolute protection from future floods must be predicated upon probable gage heights, and be measured by them. To the flood of 1912, therefore, must be assigned first place in the flood history of the lower Mississippi Valley.

DAMAGE AND LOSSES.

In the statement regarding damage and losses no attention will be paid to the impairment of the levees and the amount of money necessary to restore them. The estimates given will be limited to damage to and losses of property and crops and to the losses occasioned by the enforced suspension of business. It must be remembered that it is at all times extremely difficult to arrive at any accurate conclusion as to losses from floods, and the figures given here will, of course, be estimates only. They were, however, based upon careful observation and in many instances upon actual reports from those directly interested, and they are believed to be as accurate as it was possible to make them under the conditions existing at the time. Many losses were of such a character that the money equivalent could not be estimated and many others were unreported, so that to the total losses reported it would probably be reasonable and safe to add at least 10 per cent for others regarding which data were not available.

The losses and damage will be classified into four groups as follows:

1. Property losses and damage, exclusive of crops.
2. Crop loss and damage.
3. Damage to farm lands.
4. Losses occasioned through enforced suspension of business.

In the interest of further detail the data will also be localized by reference to existing river districts as maintained by the United States Weather Bureau, it being understood that each district includes the tributary watersheds from the headquarters of the district to the headquarters of the one immediately above.

TABLE X.—*Losses and damage occasioned by the flood of 1912.*

District.	Property, exclusive of crops.	Crops.	Damage to farm lands.	Suspension of business.
St. Louis, Mo	(1)	(1)	(1)	(1)
Evansville, Ind	(1)	(1)	(1)	(1)
Nashville, Tenn	$200,000	(2)	(2)	(2)
Cairo, Ill	153,000	$412,000	$14,000	$250,000
Memphis, Tenn	[3] 9,000,000	3,000,000		
Fort Smith, Ark	35,000	75,000	15,000	
Little Rock, Ark	(4)	(4)	(4)	(4)
Vicksburg, Miss	10,208,000	14,310,000	240,000	2,100,000
New Orleans, La	5,072,500	13,870,000	125,000	12,000,000
Total	24,668,500	31,667,200	394,000	14,350,000
Plus 10 per cent for unreported losses	2,466,850	3,166,720	39,400	1,435,000
Total	27,135,350	34,833,920	433,400	15,785,000

Grand total, $78,187,670.

[1] No serious damage except delay to farming operations.
[2] Impossible to obtain estimates.
[3] Includes all except crops.
[4] No serious damage. Some replanting necessary.

The losses sustained by the railroads were about $4,000,000, or a little more than 5 per cent of the total amount.

As stated before, these figures are approximate only. They were compiled with care and it is believed that any errors would lean toward the conservative side as a whole. There were innumerable losses of many kinds that could not be reduced to the basis of dollars and cents, and if the actual truth concerning these could have been ascertained, it is probable that the totals as given above would be exceeded by several millions of dollars.

Above Cairo, where there was little overflow, the total losses were but a little over $1,000,000. In the Memphis district, where the overflowed lands comprised an area of 3,142 square miles, the losses were about $12,000,000, or nearly $4,000 per square mile, of which nearly $1,000 per square mile was in crops, actual or prospective. It was assumed that 15 per cent of the overflowed area would not be replanted, and that 30 per cent of the remainder would bear only a minimum crop because of the late planting. In the Vicksburg district the overflowed area was 5,463 square miles in extent and the losses as furnished totaled $26,858,000, or about $4,900 per square mile, of which over $2,600 per square mile was in crops, actual or prospective, it being assumed that not more than two-thirds of a full crop would be raised during the year. In the New Orleans district the overflowed area amounted to about 9,000 square miles and the losses were estimated at $31,067,700, or about $3,452 per square mile, of which about $1,541 per square mile was in crops, actual or prospective.

The total extent of the overflowed area was 17,605 square miles, or 59 per cent of the entire area subject to overflow previous to 1897. This would make the average loss per square mile about $4,440, of which nearly $1,980 per square mile was in crops, actual or prospective. In 1897 the overflowed area amounted to 13,578 square miles, about 4,000 square miles less than in 1912, and about 45 per cent of the entire area subject to overflow, or 14 per cent less than in 1912. In 1903 the water overflowed an area of only 6,820 square miles, or slightly less than 23 per cent of the entire area subject to overflow. No estimates were made of the losses occasioned by these two latter floods, but they were doubtless less per square mile than in 1912, as both occurred earlier in the season, thereby largely reducing the item of prospective crop loss. Values were also considerably lower in 1897 and 1903 than in 1912.

THE WORK OF THE WEATHER BUREAU IN THE FORECASTING OF FLOODS.

The most important function of the Weather Bureau in connection with the conduct of its river and flood service is the preparation and issue of river forecasts and flood warnings. It is not a matter of general knowledge that forecasts of coming stages are issued daily along all the navigable rivers, and that to the uniform correctness of these forecasts is due a large share of whatever of success and prosperity has attended river navigation. Flood forecasts are issued for all except the smallest rivers, and with this feature of the work the public is more familiar.

Precision in the work of river and flood forecasting was first attempted in 1892, and since that time the work has been prosecuted with such constantly increasing success and accuracy that at the present time the variations of the actual from the forecast stages in all except the precipitous mountainous streams are practically negligible, and this notwithstanding the fact that the work from Cairo southward has been greatly complicated at times by reason of levee crevasses. Let us quote briefly from Bulletin E, Weather Bureau, Floods of the Mississippi River, Section IV, paragraph 83:

> The essential duty of the Weather Bureau in this work is the issuance of warnings of impending floods. For this purpose the official at each river center is assigned a certain territory, for the proper warning of which he is held responsible. From the press reports and other sources of information it appears that this duty was well performed in the late flood (1897). The conditions having become critical, a special warning was issued from the Washington office on March 15 that "the impending flood will prove very destructive in Arkansas and northern Louisiana." Again, on March 19, a special warning was issued that "the floods in the lower Mississippi during the next ten days or two weeks will, in many places, equal or exceed in magnitude and destructiveness those of any previous years, and additional warning is given to the residents of the threatened districts in Arkansas, Louisiana, and western Mississippi to remove from the region of danger." Indeed, so completely was the public warned, that it caused criticism in certain quarters that the bureau was needlessly alarming the people in the threatened districts. Subsequent events, however, fully justified the action of the Weather Bureau.

Similar criticism was made during the flood of 1903 and again during the present year, but in less pronounced form, as previous said experiences had taught the people that the warnings of the Weather Bureau must be taken at their full significance if loss of life and property are to be avoided. It is estimated that during the flood of 1897 property to the value of $15,000,000 was moved to places of safety as a result of the Weather Bureau warnings, and an equal amount, at least, during the flood of 1903. During the flood of 1912, according to such estimates as were obtainable, property to the value of $16,180,000 was saved, of which about $10,000,000 was in the district below Vicksburg, Miss. The total annual cost of the river and flood service for the entire country, including telegraph and telephone tolls is about $80,000, or only about one-half of 1 per cent of the value of the property saved in this one flood.

Specific warnings were issued each day during the flood, and they covered periods of time ranging from three or four days to more than four weeks in advance. The warnings for New Orleans were issued nearly five weeks in advance, and were not changed in the interim except as to the date of occurrence of the crest stage, the numerous crevasses at times interfering with the rate of streamflow.

General warnings and statements were also issued from time to time at the central office at Washington. A specimen bulletin follows:

U. S. Department of Agriculture,
Weather Bureau,
Washington, D. C., April 3, 1912.

SPECIAL FLOOD BULLETIN.

> The river situation is critical from Cairo to the mouth of the Mississippi. If the levees hold, the floods will doubtless be the greatest of which the Government has record.
>
> Considering the water now in sight, and without any further heavy rain, the Mississippi River below Vicksburg will rise until the early part of May, and if the levees hold the river will reach about 52 feet at Natchez, 42 feet at Baton Rouge, 33.5 feet at Donaldsonville, and 21.5 feet at New Orleans. These figures are from 1 to 1.5 feet higher than any previous record.
>
> The warning issued Tuesday for at least 44 feet at Memphis by Saturday or Sunday, if the levees hold, is repeated and preparations should be made accordingly. The highest water at Memphis previous to the present flood was 40.3 feet on February 3, 1907.

At Vicksburg the 50-foot stage will be passed by Saturday or Sunday, and if the levees hold a stage of between 53.5 and 54 feet is likely to occur later. The highest known water at Vicksburg is 52.5 feet, which occurred on April 16, 1897.

Helena, Ark., will pass the 50-foot stage some time to-day and continue to rise, but the greatest stage can not be forecast at this time, owing to the uncertainty as to the overflow water above.

At Cairo the stage of 56 feet, which was forecast yesterday to occur within three or four days, will not be reached because of the breaking of the levees below the city, and it is probable that the greatest stage will be reached within two days, but not much over 54 feet.

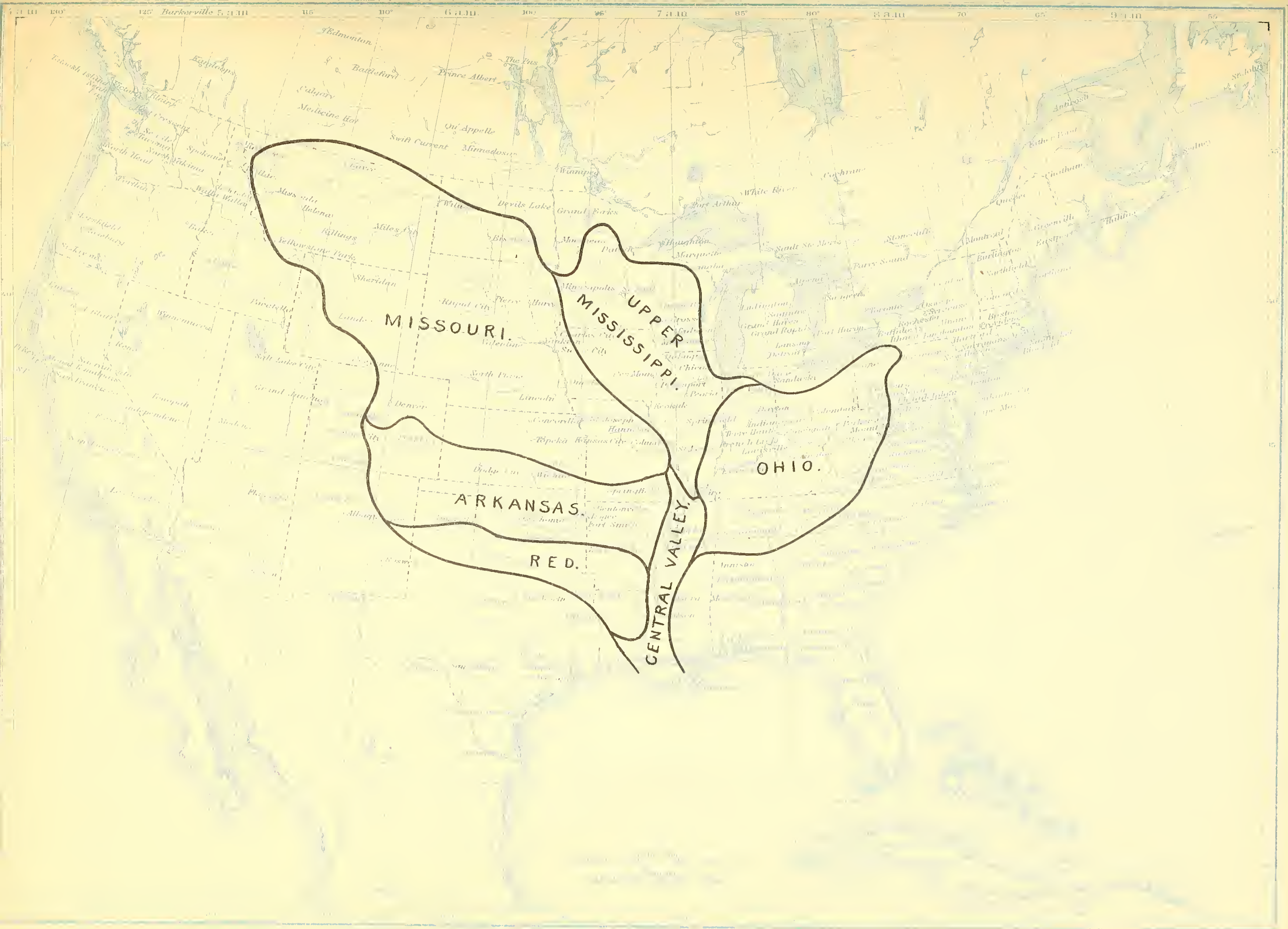
Warnings of the beginning of these floods were issued by the Weather Bureau as early as March 16, and in each case have preceded the arrival of flood stages.

Willis L. Moore,
Chief U. S. Weather Bureau.

These bulletins, as well as all forecasts and warnings, were given the widest and most liberal distribution through the medium of the telegraph, the telephone, the mails, railroads, boats, special messengers, and every other available means, so that all the inhabitants of the flooded districts were given ample advance notice as well as the fullest information during the progress of the flood.

A great many testimonials, press and otherwise, were received. These paid tribute to the work of the Weather Bureau in connection with the flood.

Drainage Basin of the Mississippi River.



Weather Map. 8 a. m., March 11, 1912, and precipitation during following 24 hours.

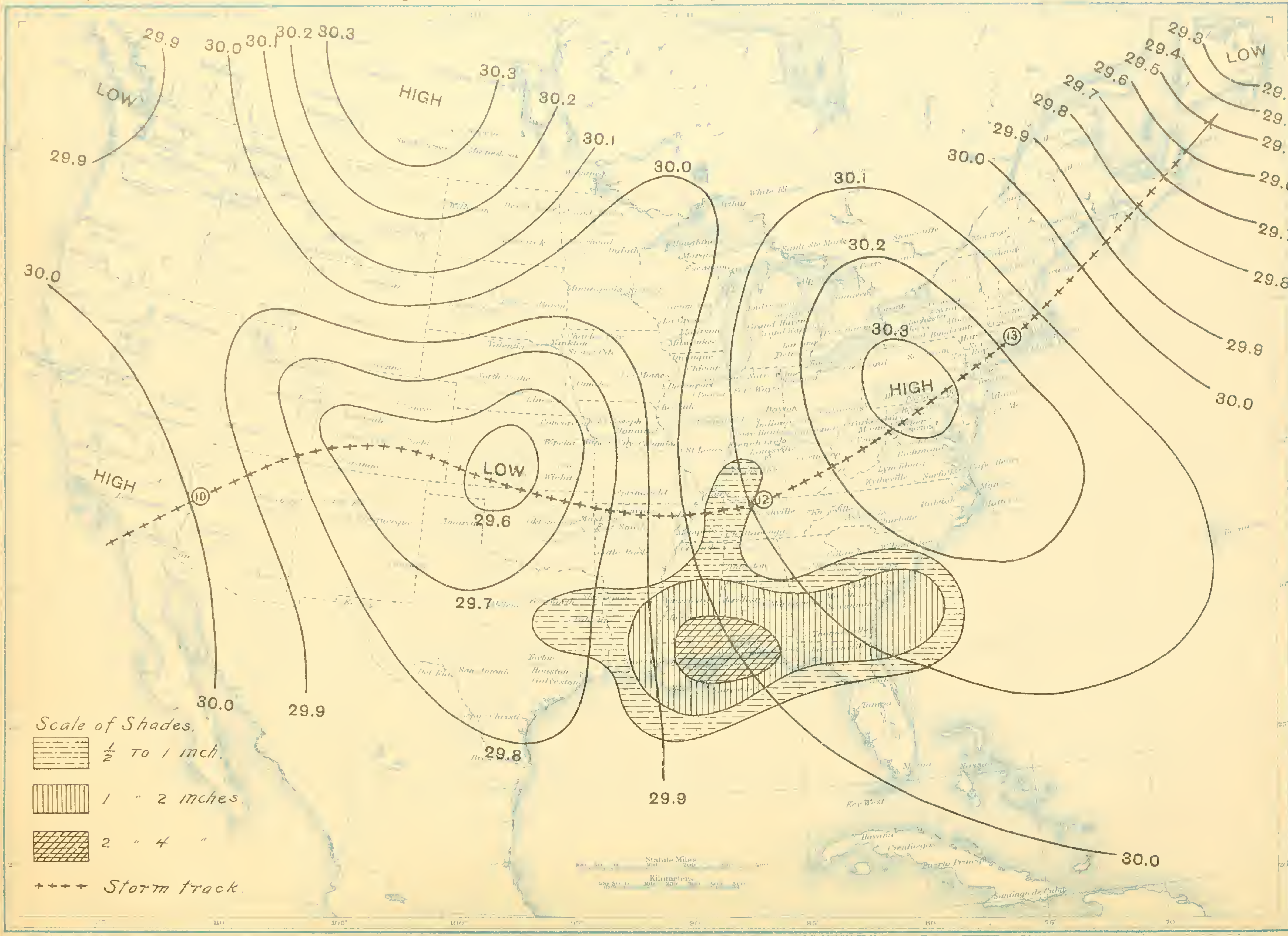


Chart 3, Part 1. Weather Map, 8 a. m., March 14, 1912, and precipitation during following 24 hours.

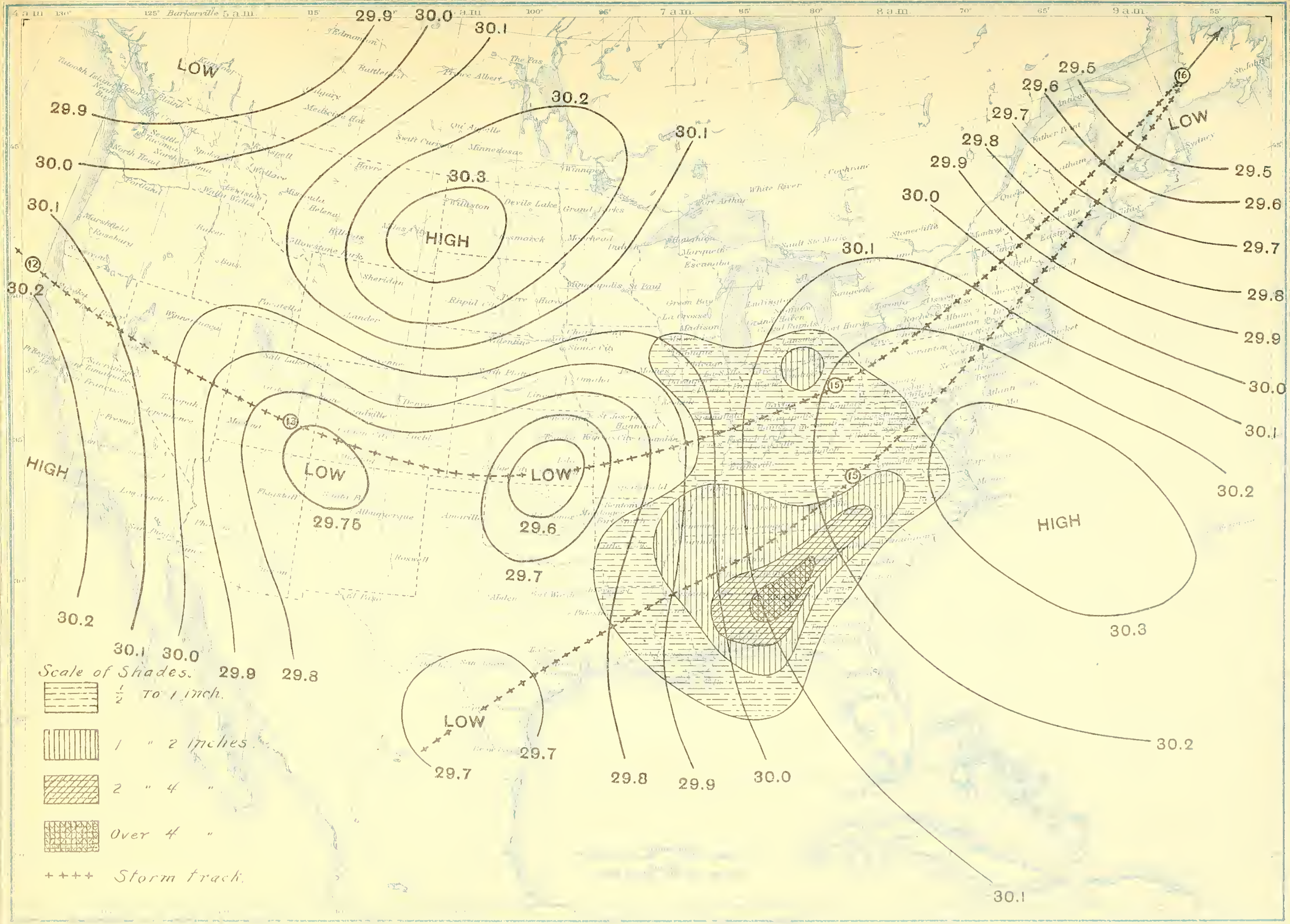


Chart 4, Part 1. Weather Map, 8 a. m., March 20, 1912, and precipitation during following 24 hours.

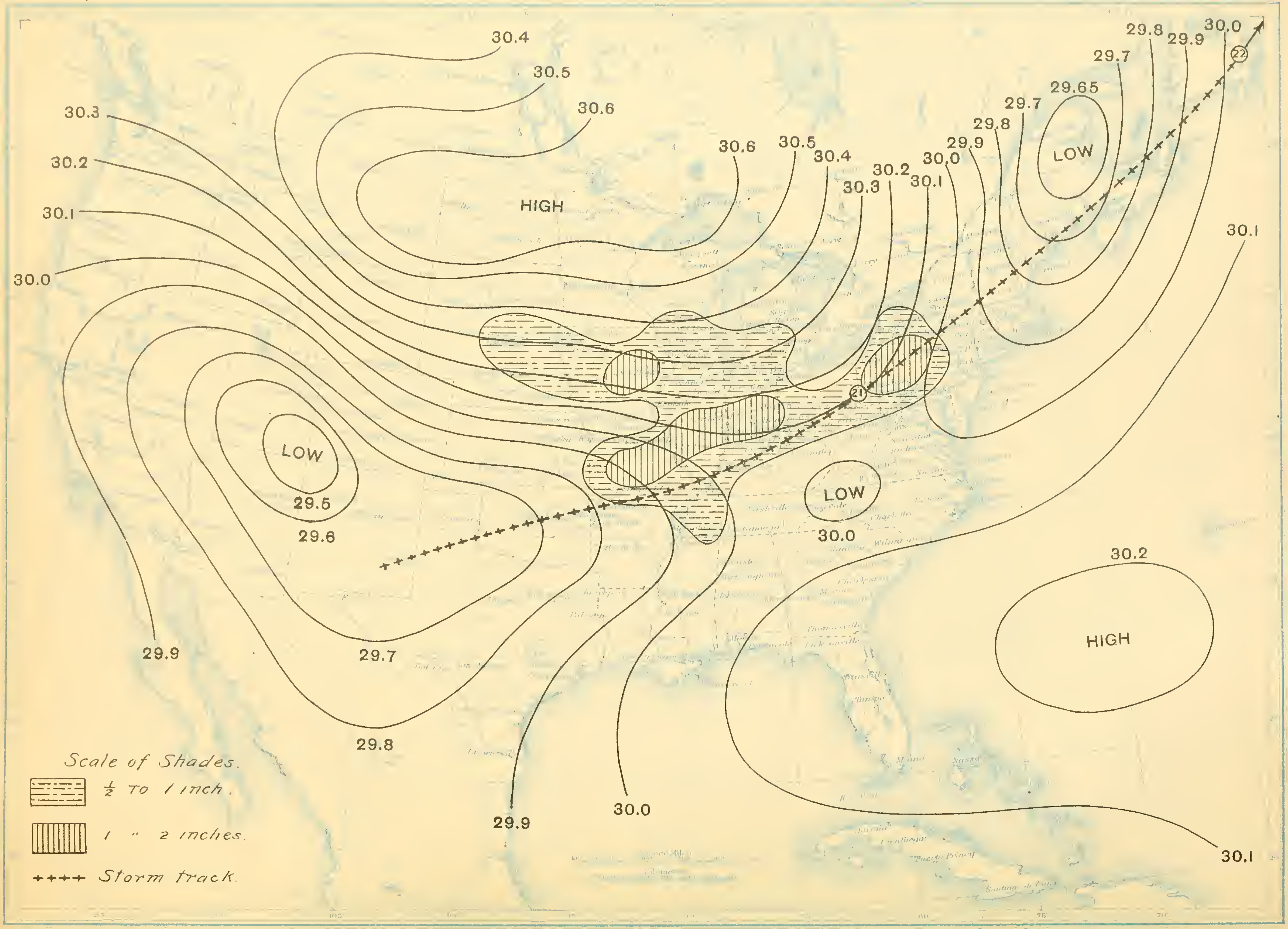
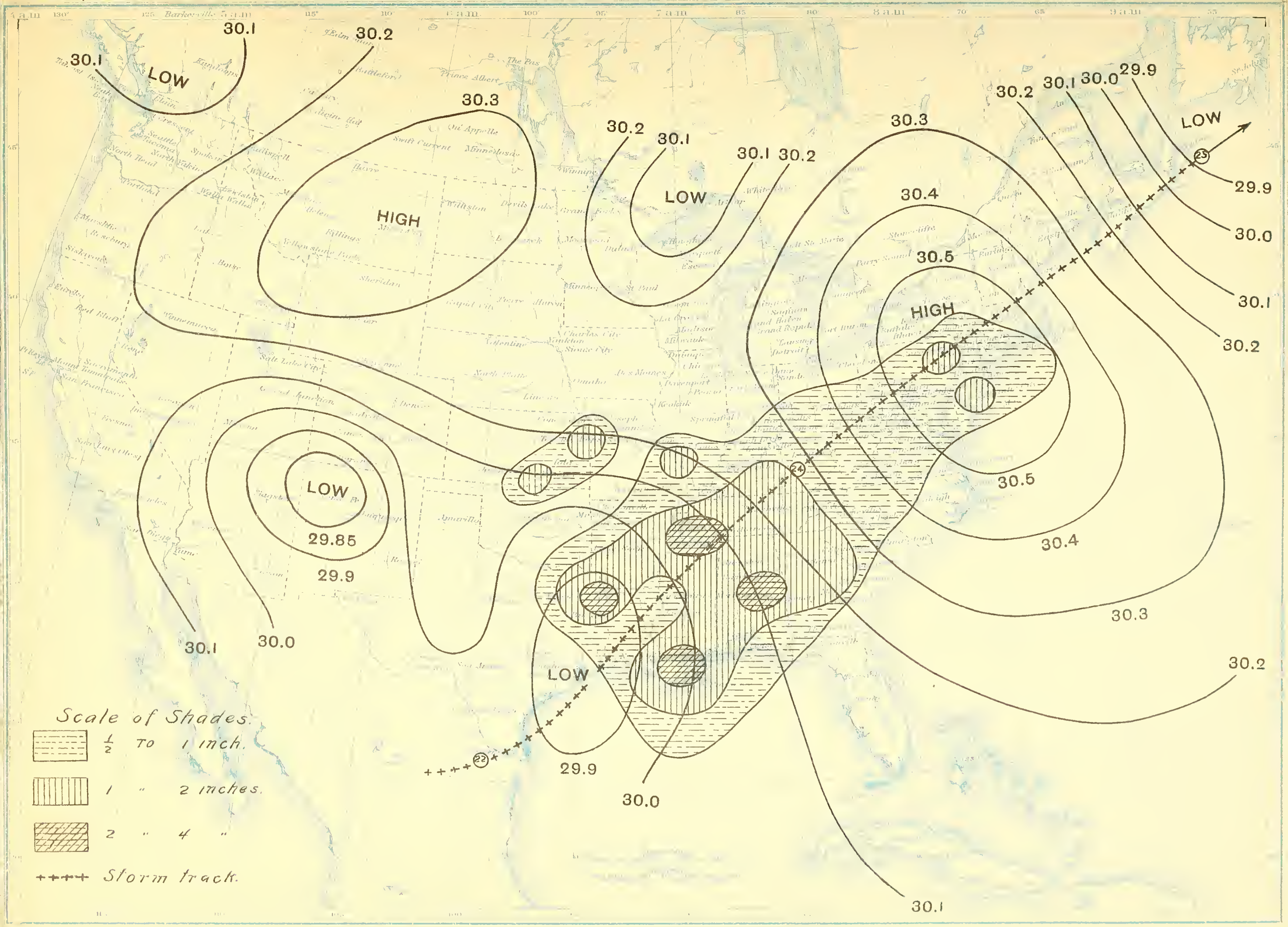
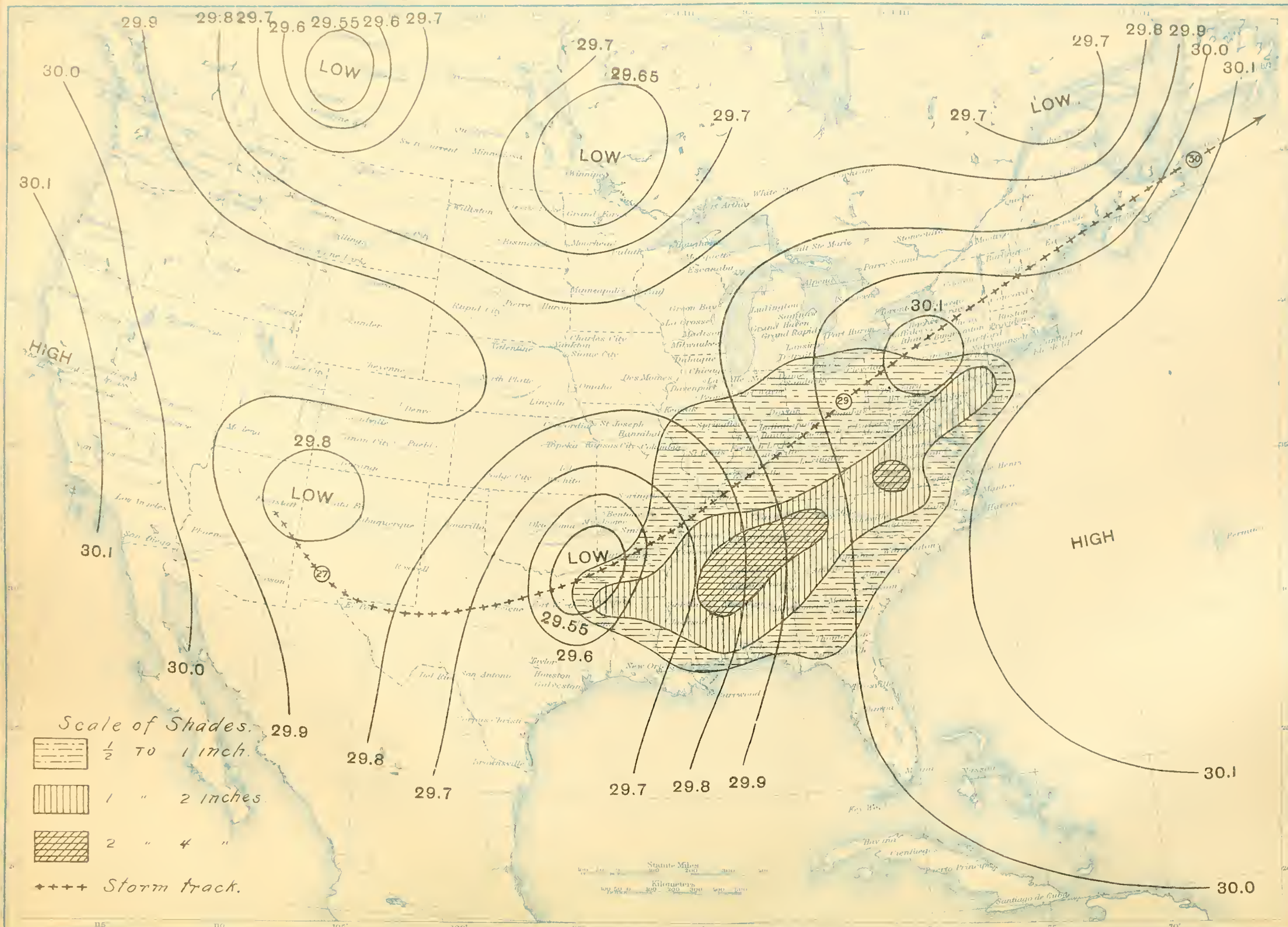


Chart 5, Part 1. Weather Map, 8 a. m., March 23, 1912, and precipitation during following 24 hours.



Weather Map, 8 a. m., March 28, 1912, and precipitation during following 24 hours.



Weather Map, 8 a. m., April 1, 1912, and precipitation during following 24 hours.

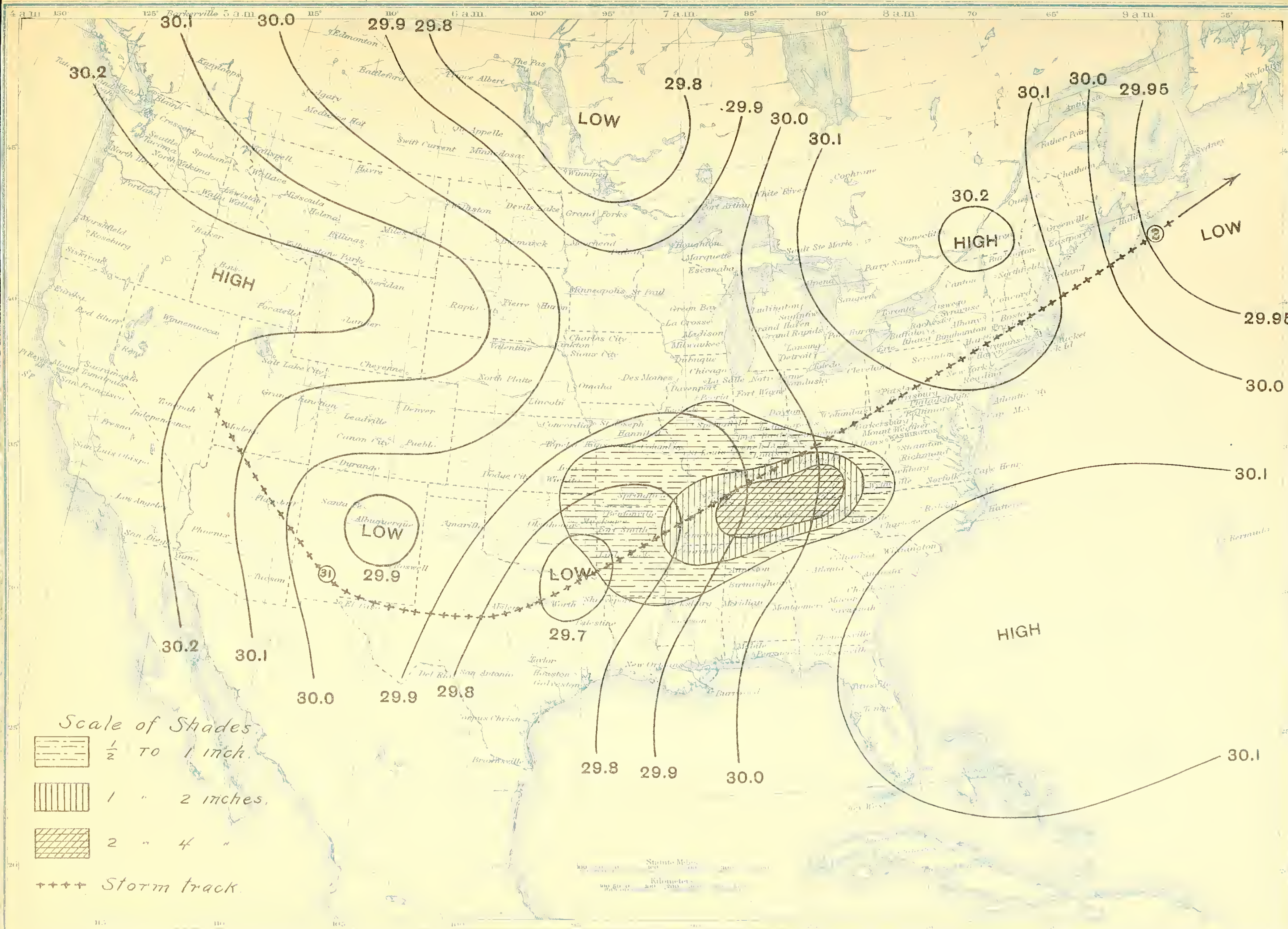


Chart 8, Part 1.

Depth of snow on ground March 4, 1912 (inches).

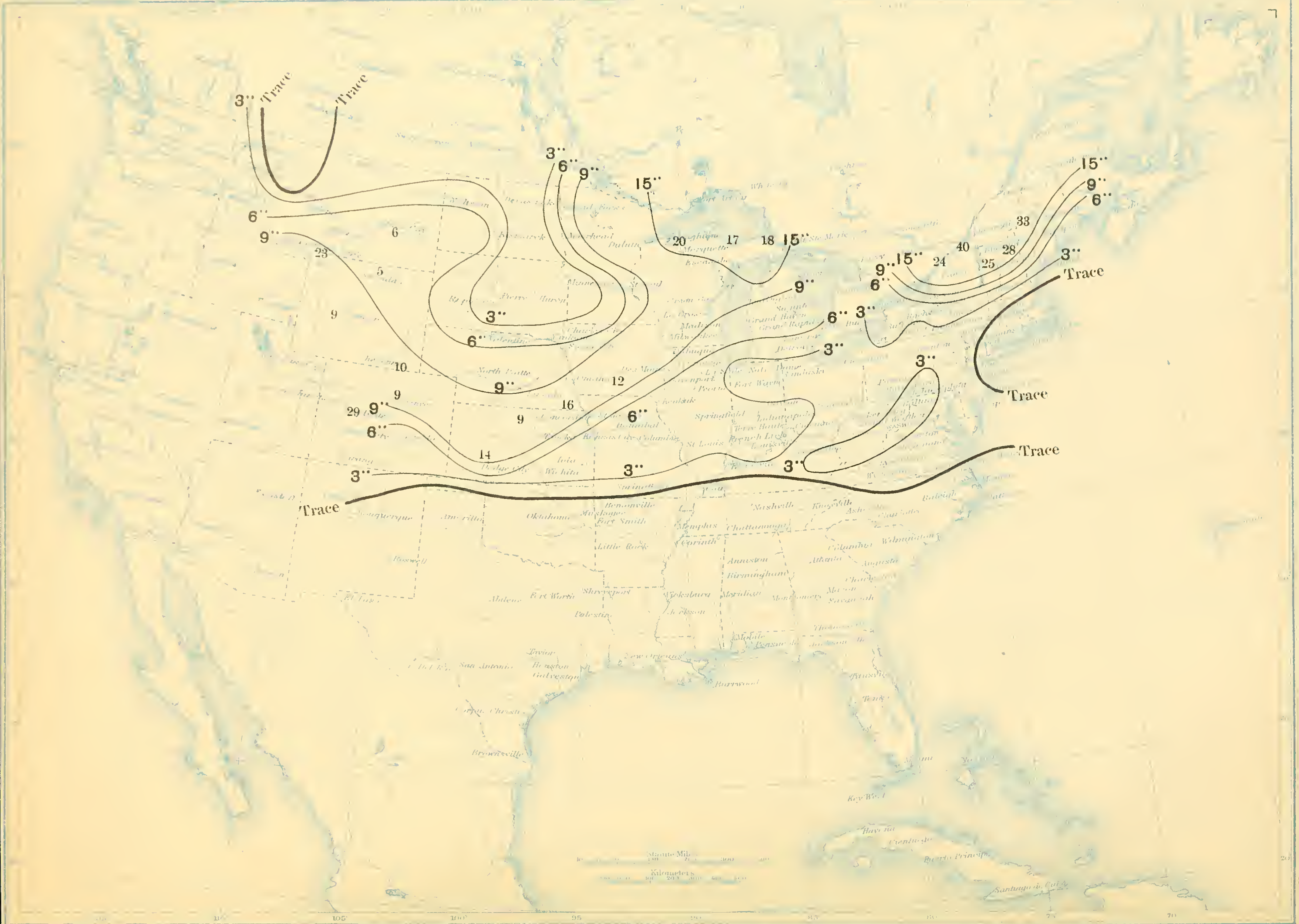


Chart 9, Part 1.

Depth of snow on ground March 11, 1912 (inches).

Chart 10, Part 1.

Depth of snow on ground March 18, 1912 (inches).

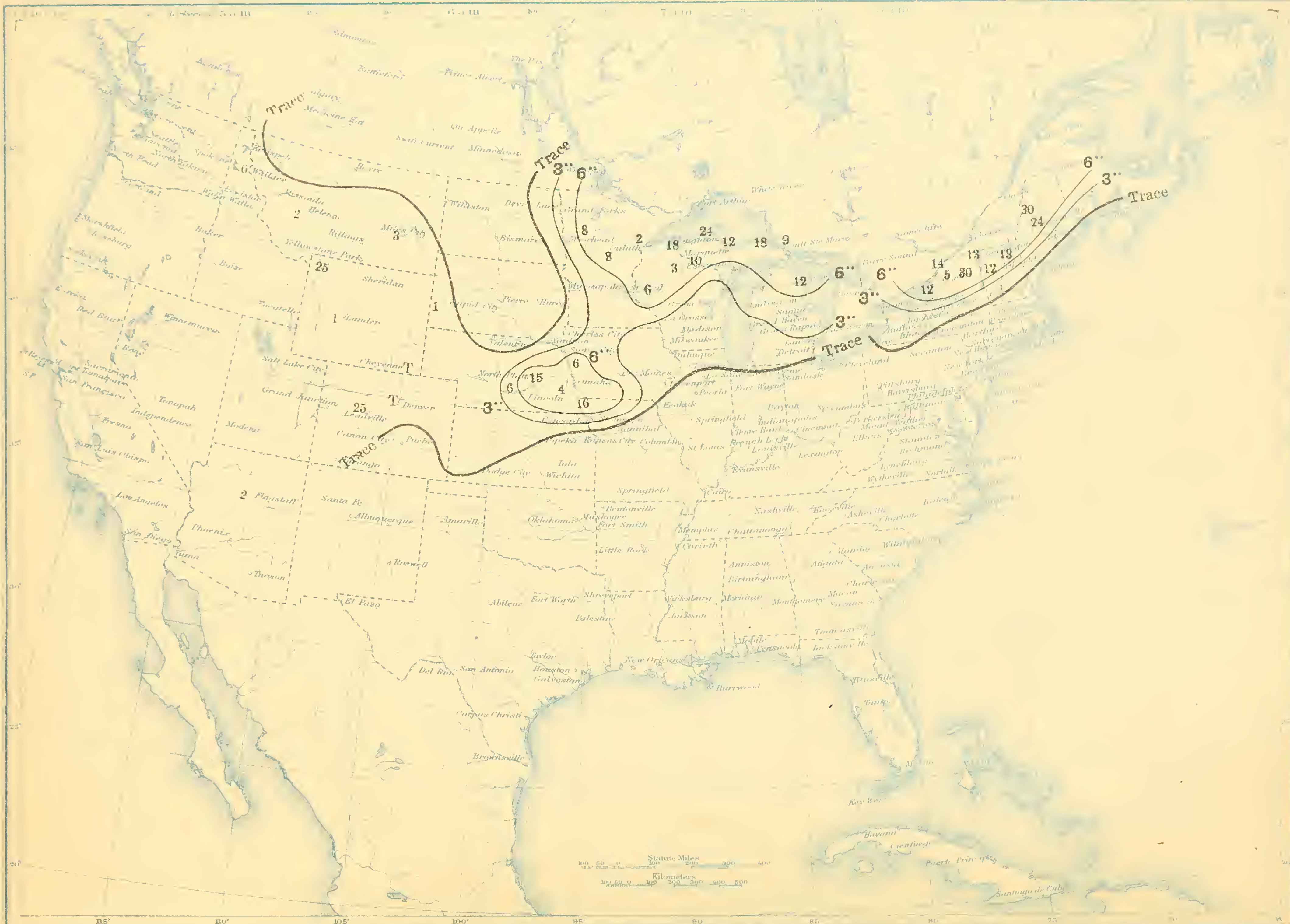


Chart 11, Part 1. Depth of snow on ground March 25, 1912 (inches).

Chart 12, Part 1.

Normal and actual precipitation, January, 1912 (inches).

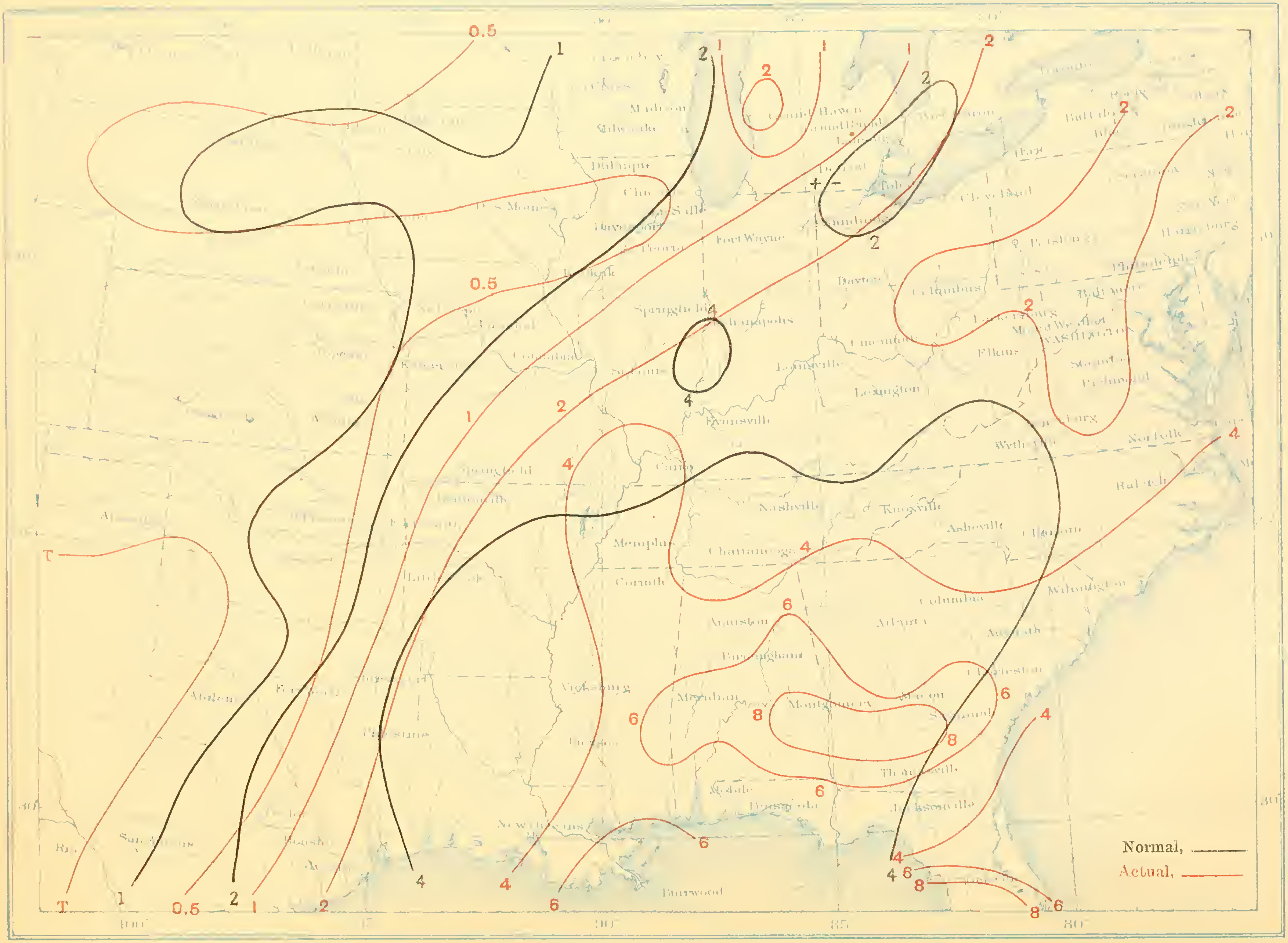


Chart 13, Part 1.

Normal and actual precipitation, February, 1912 (inches).

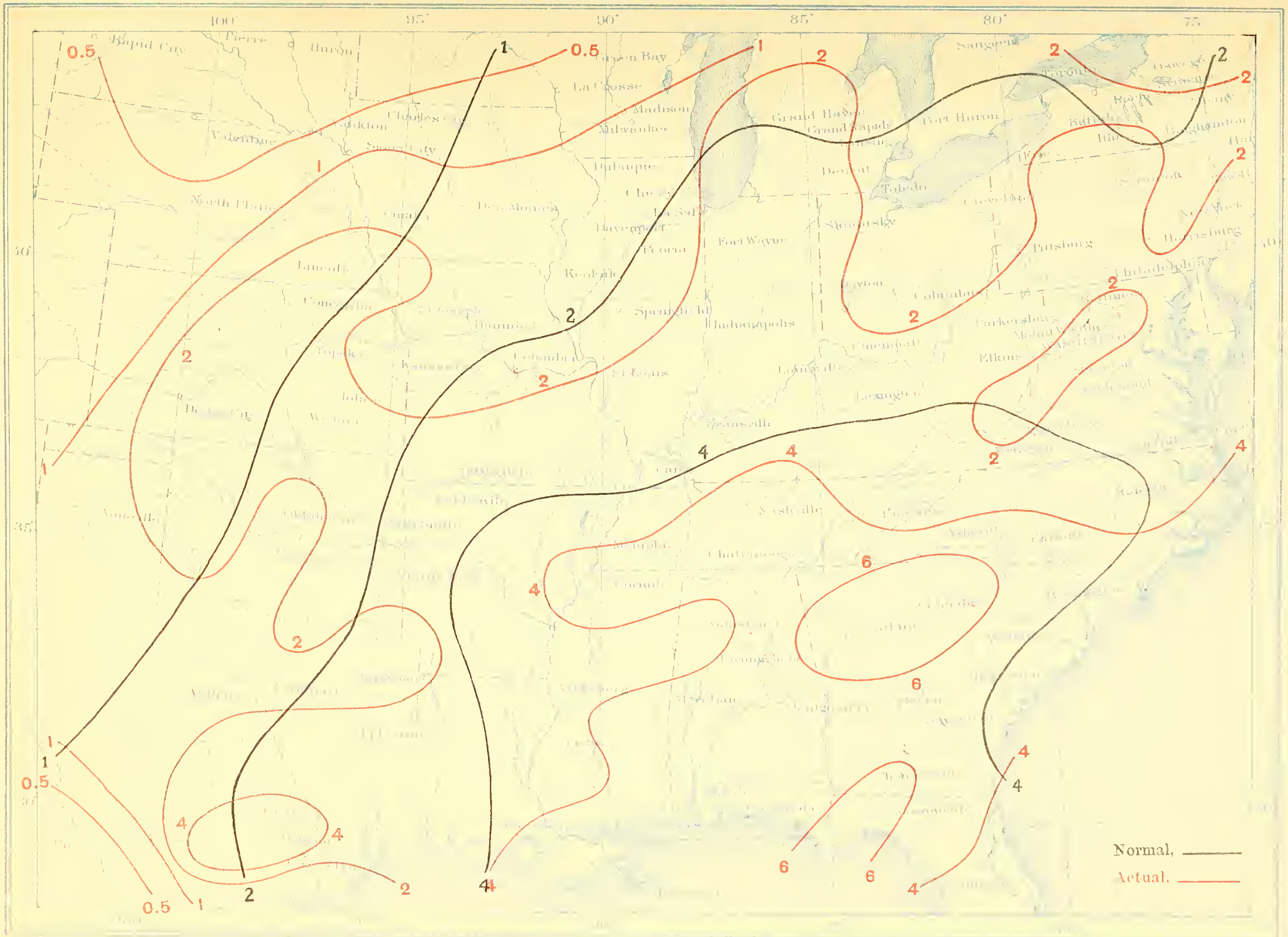


Chart 14, Part 1.

Normal and actual precipitation, March, 1912 (inches).

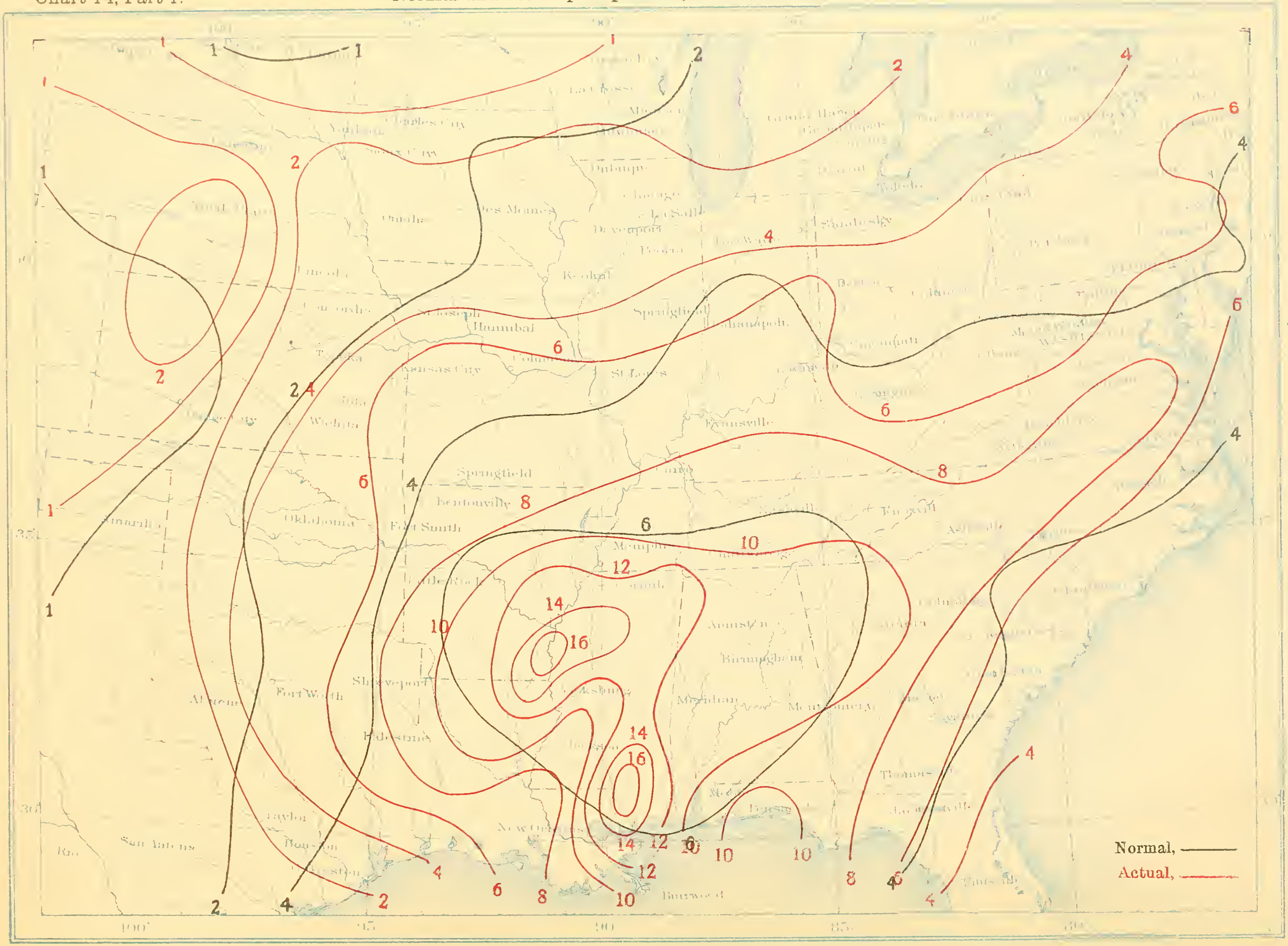
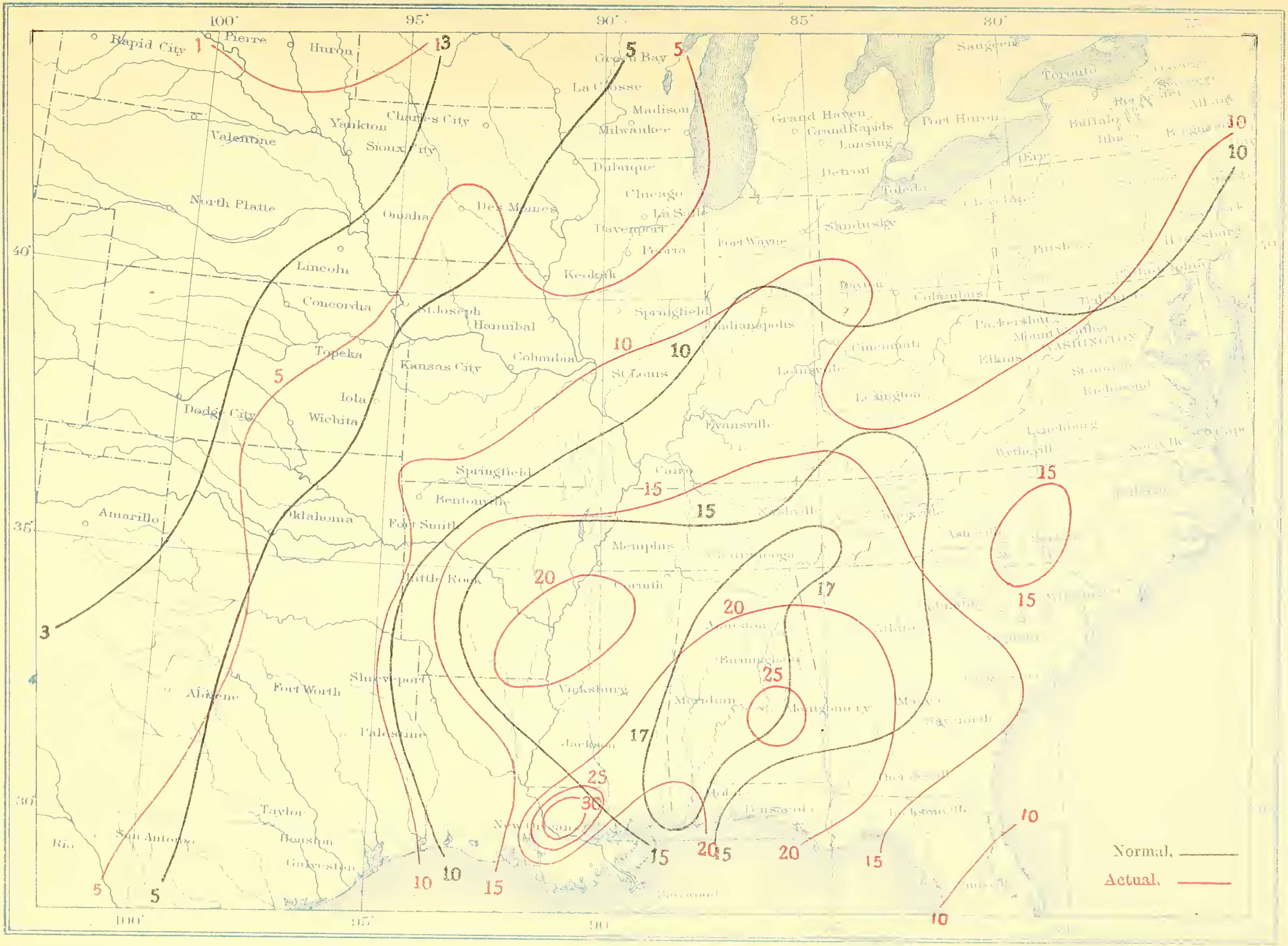


Chart 15, Part 1. Normal and actual precipitation, January 1 to April 2, 1912 (inches).



Departure from normal precipitation, January, 1912 (inches).

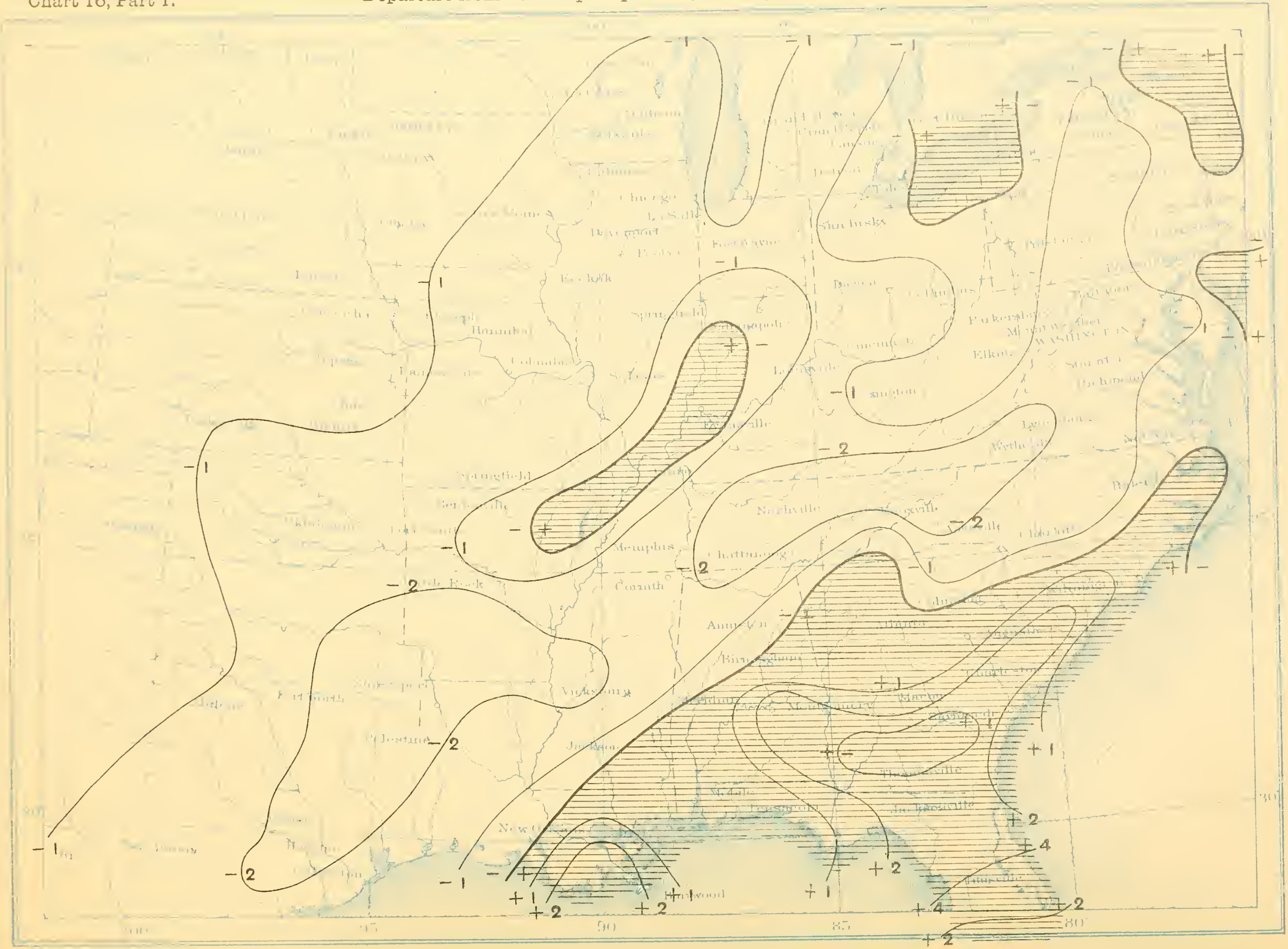


Chart 17, Part 1. Departure from normal precipitation, February, 1912 (inches).

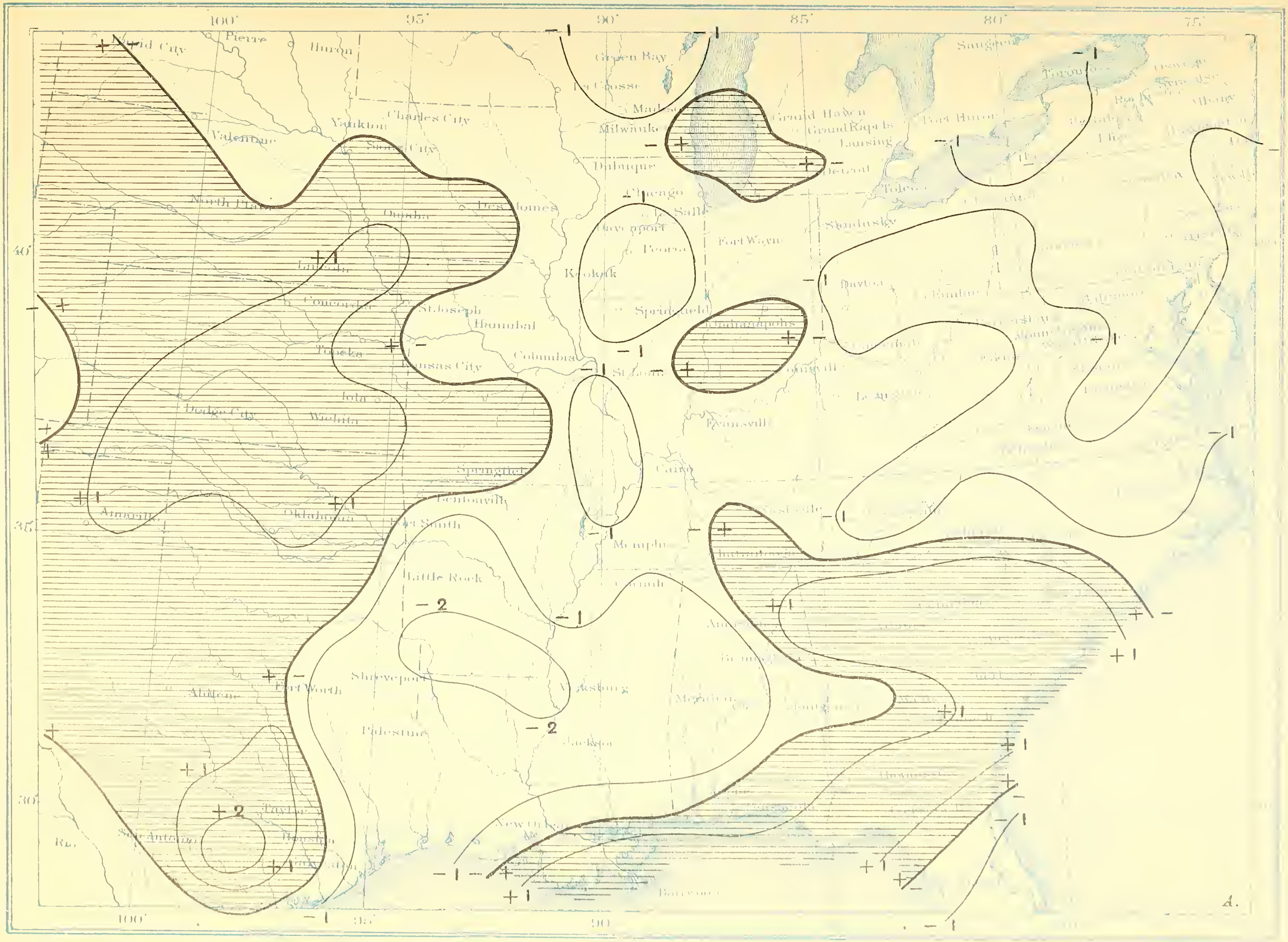


Chart 18, Part 1

Departure from normal precipitation, March 1 to April 2, inclusive, 1912 (inches).

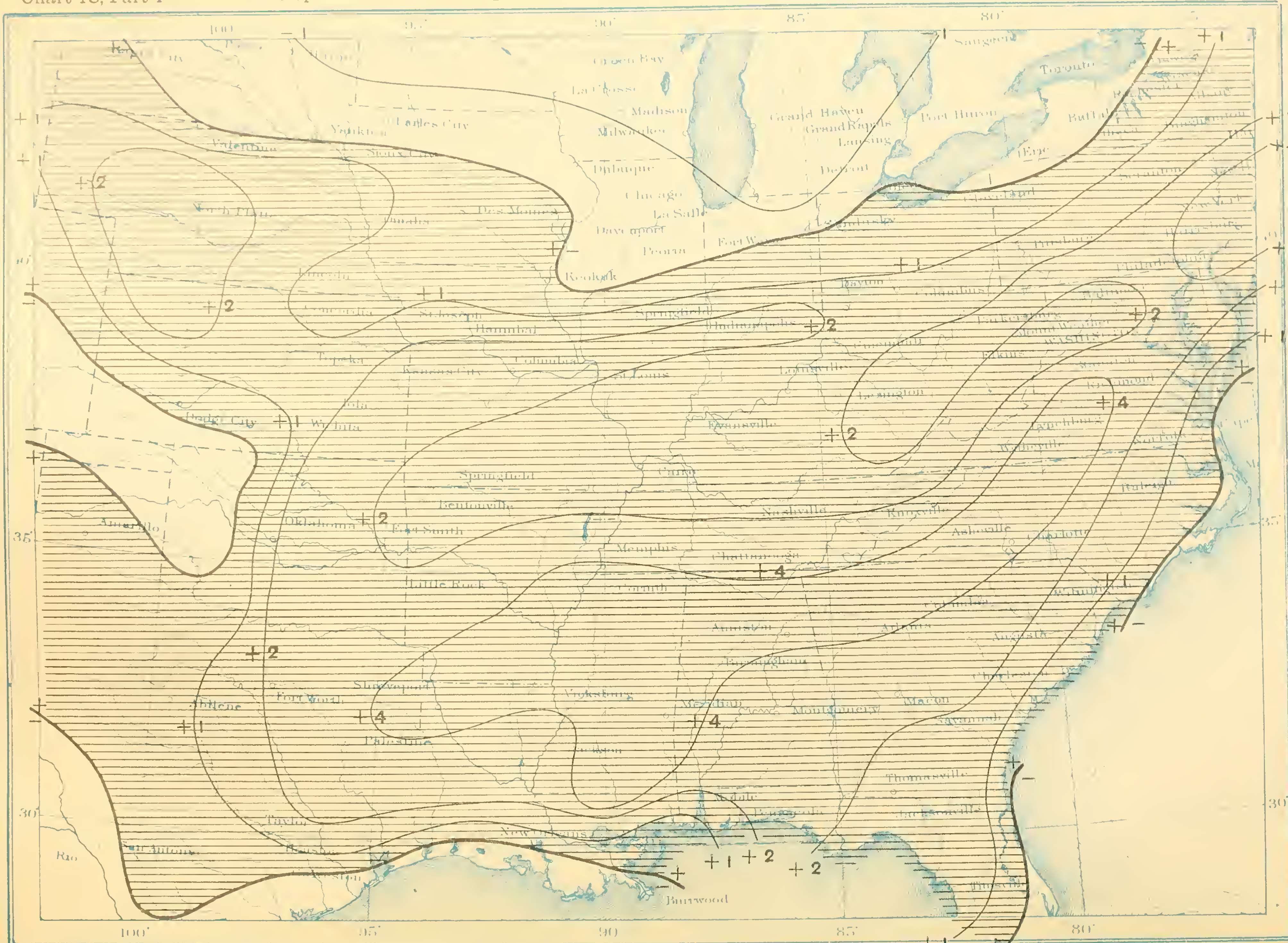
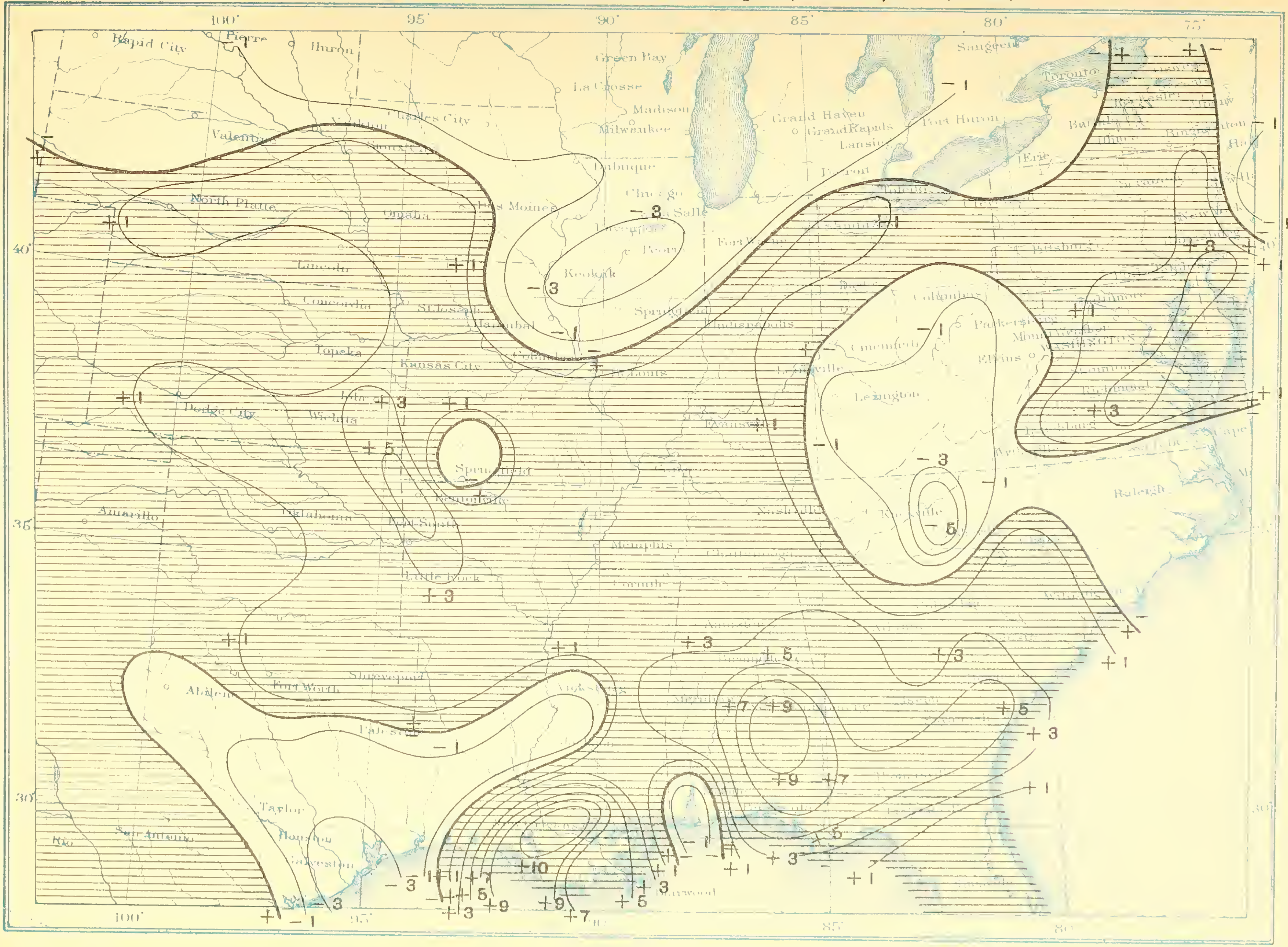


Chart 19, Part 1. Departure from normal precipitation, January 1 to April 2, inclusive, 1912 (inches).



Normal and actual precipitation, January, 1882 (inches).

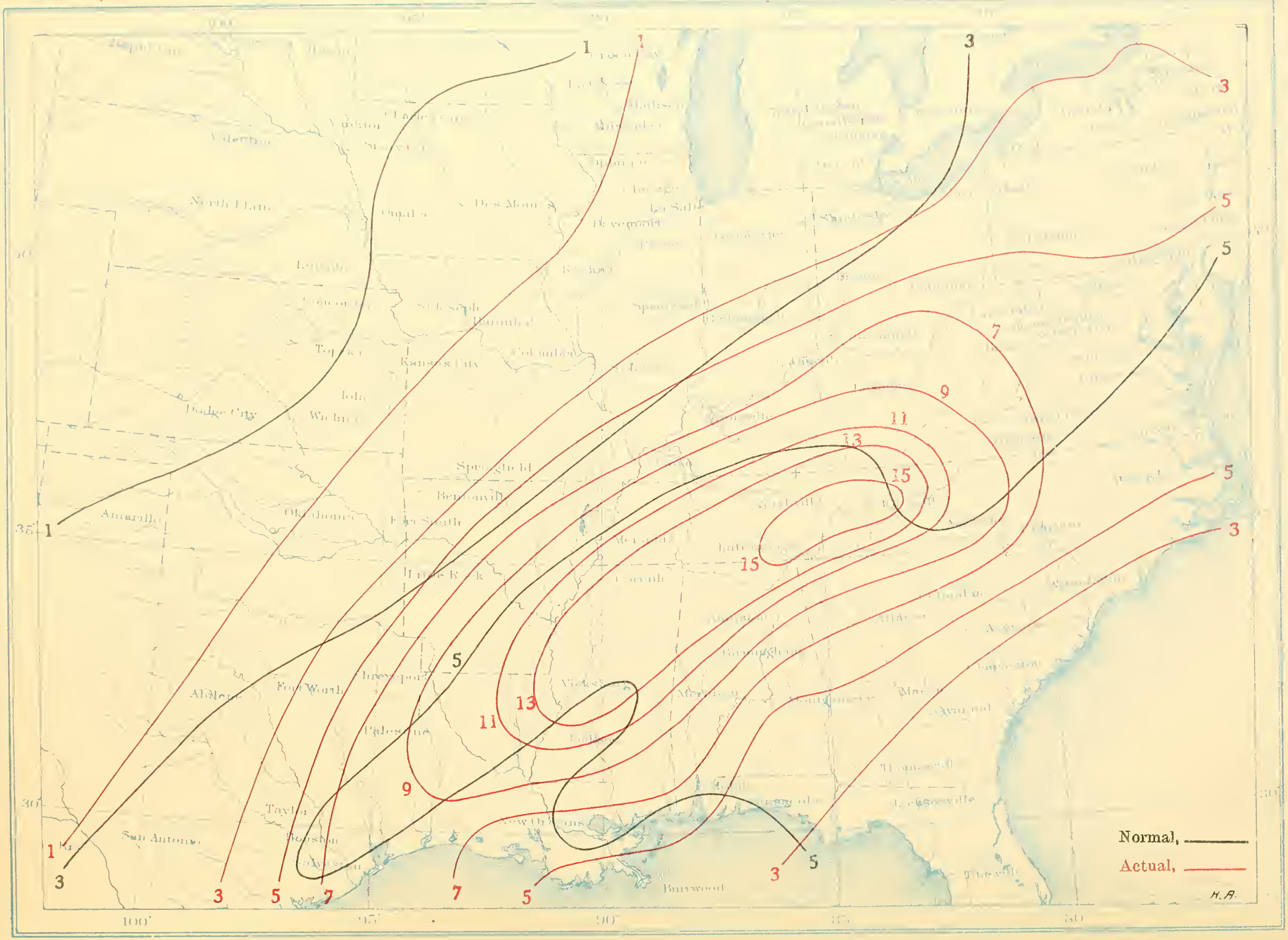


Chart 21, Part 1. Normal and actual precipitation, February, 1882 (inches).

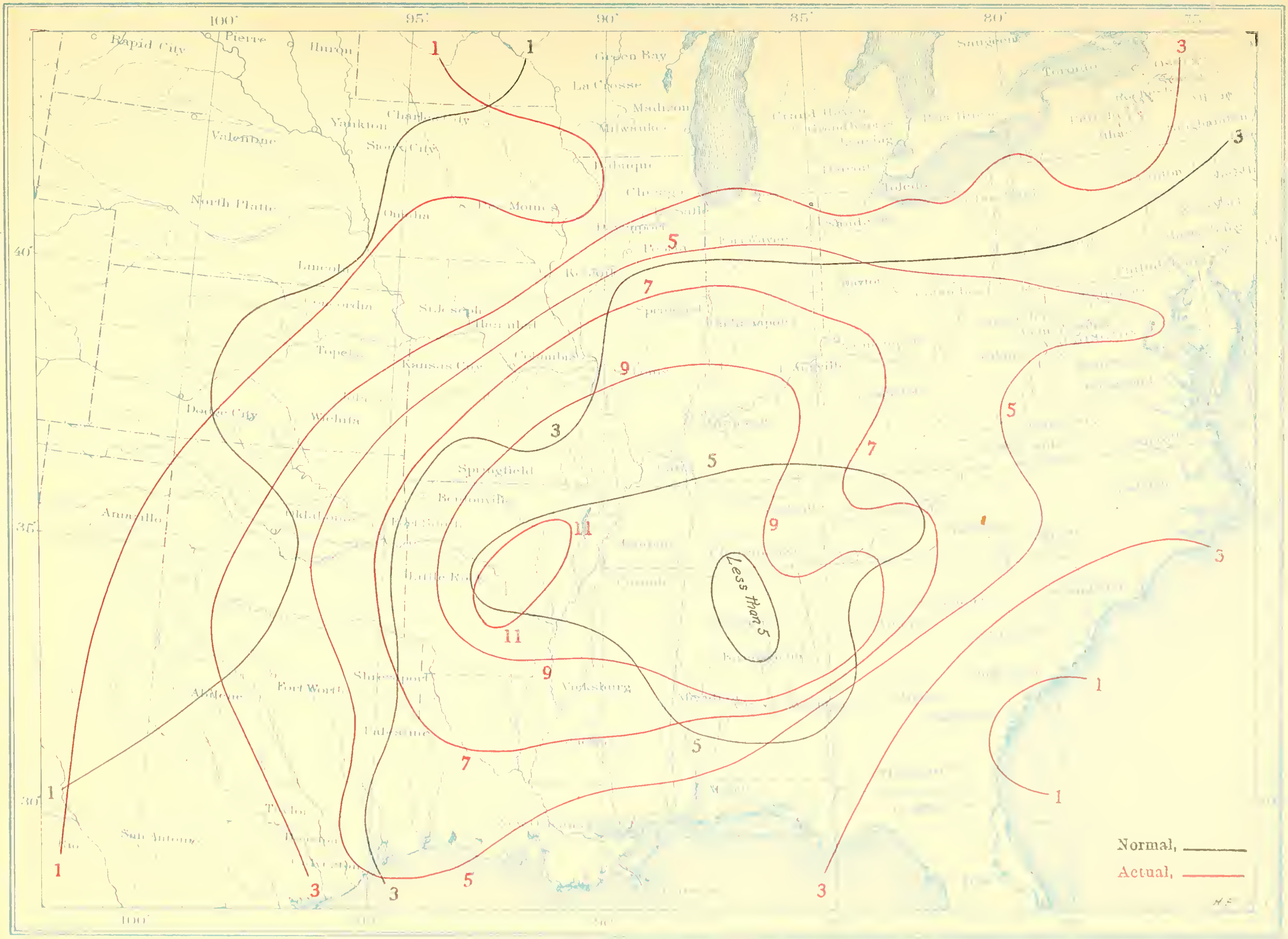


Chart 22, Part 1. Normal and actual precipitation, March, 1882 (inches).

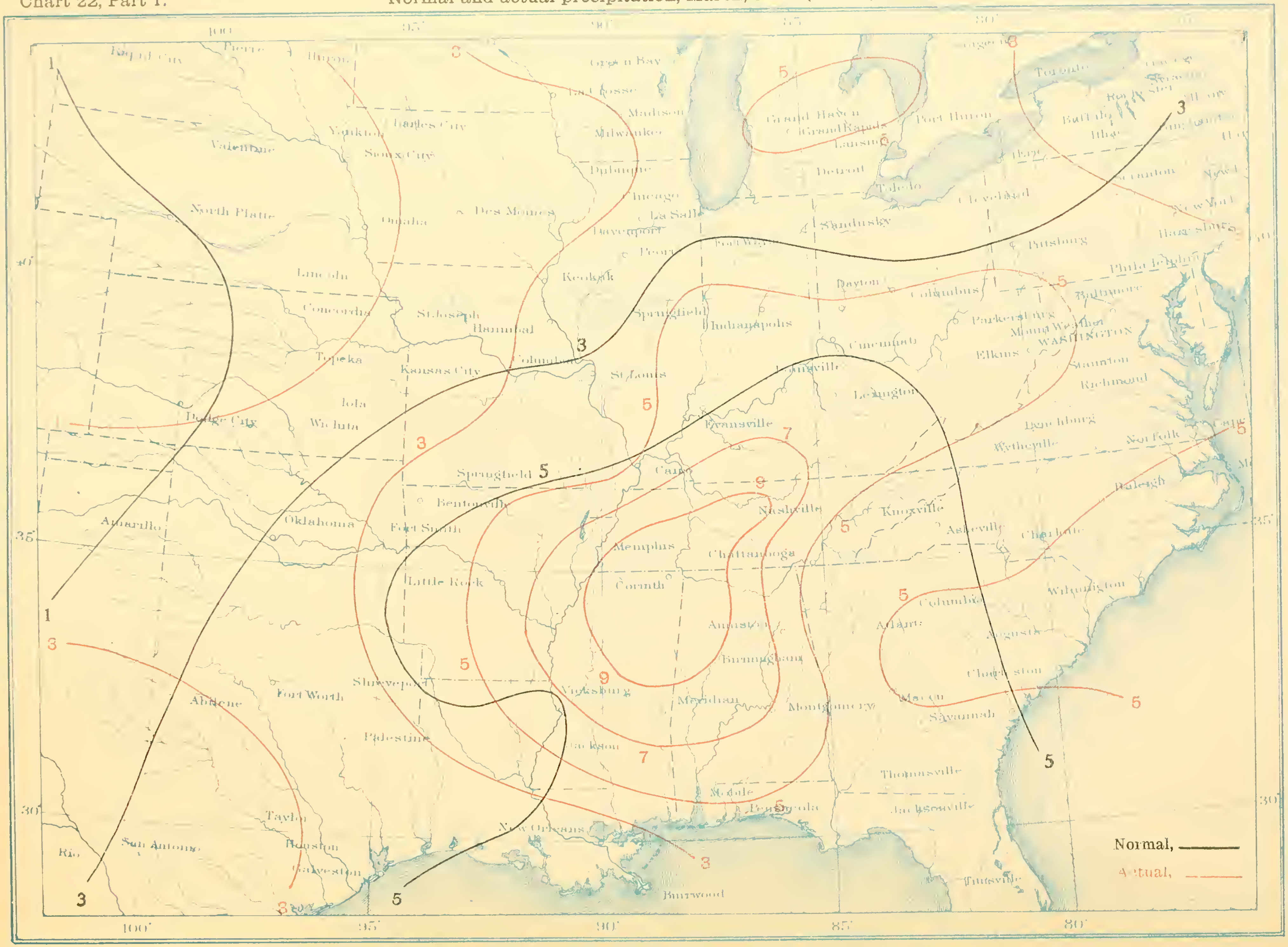


Chart 23, Part 1. Normal and actual precipitation, January and February. 1882 (inches).

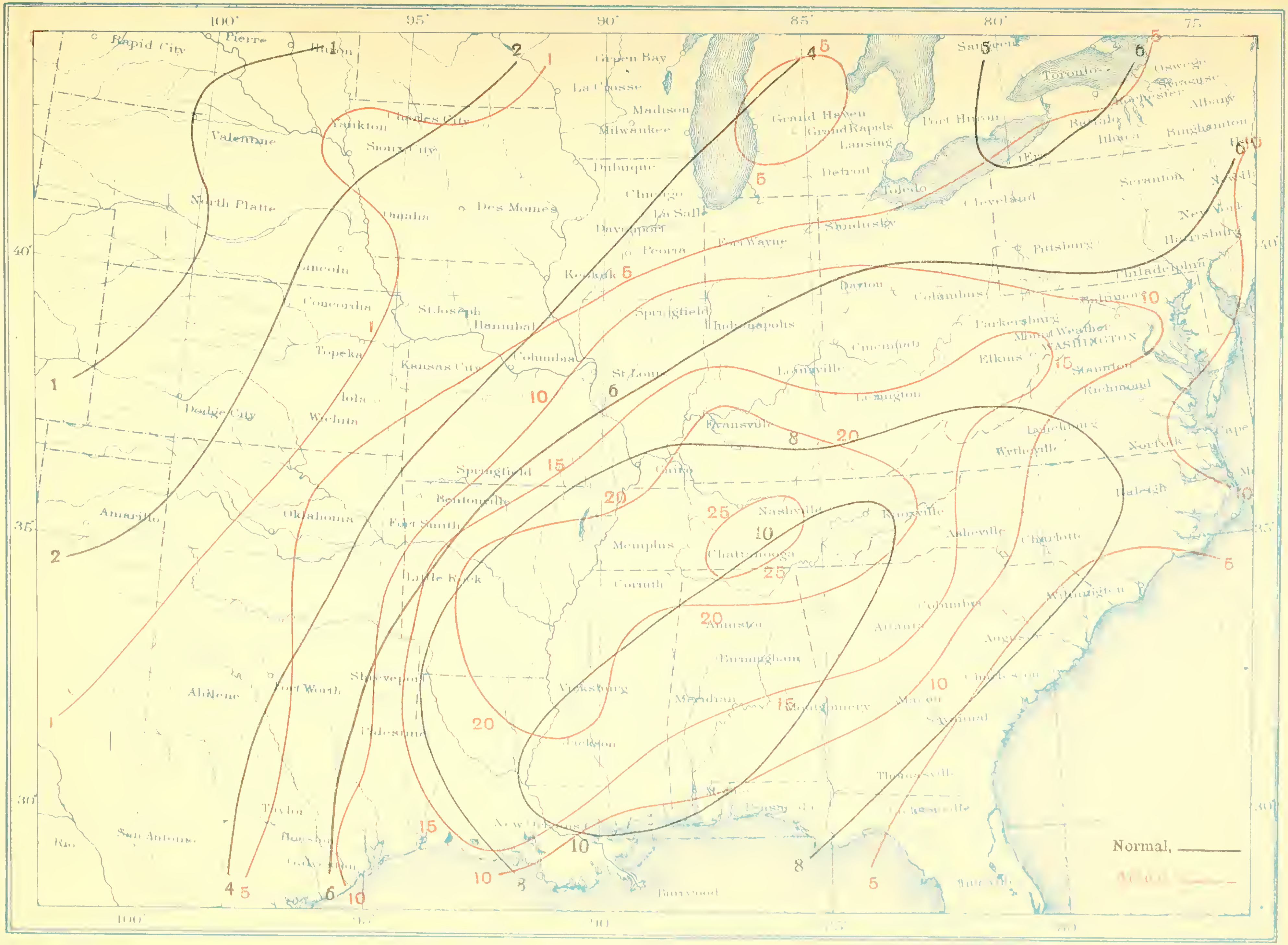


Chart 24, Part 1.

Departure from normal precipitation, January, 1882 (inches).

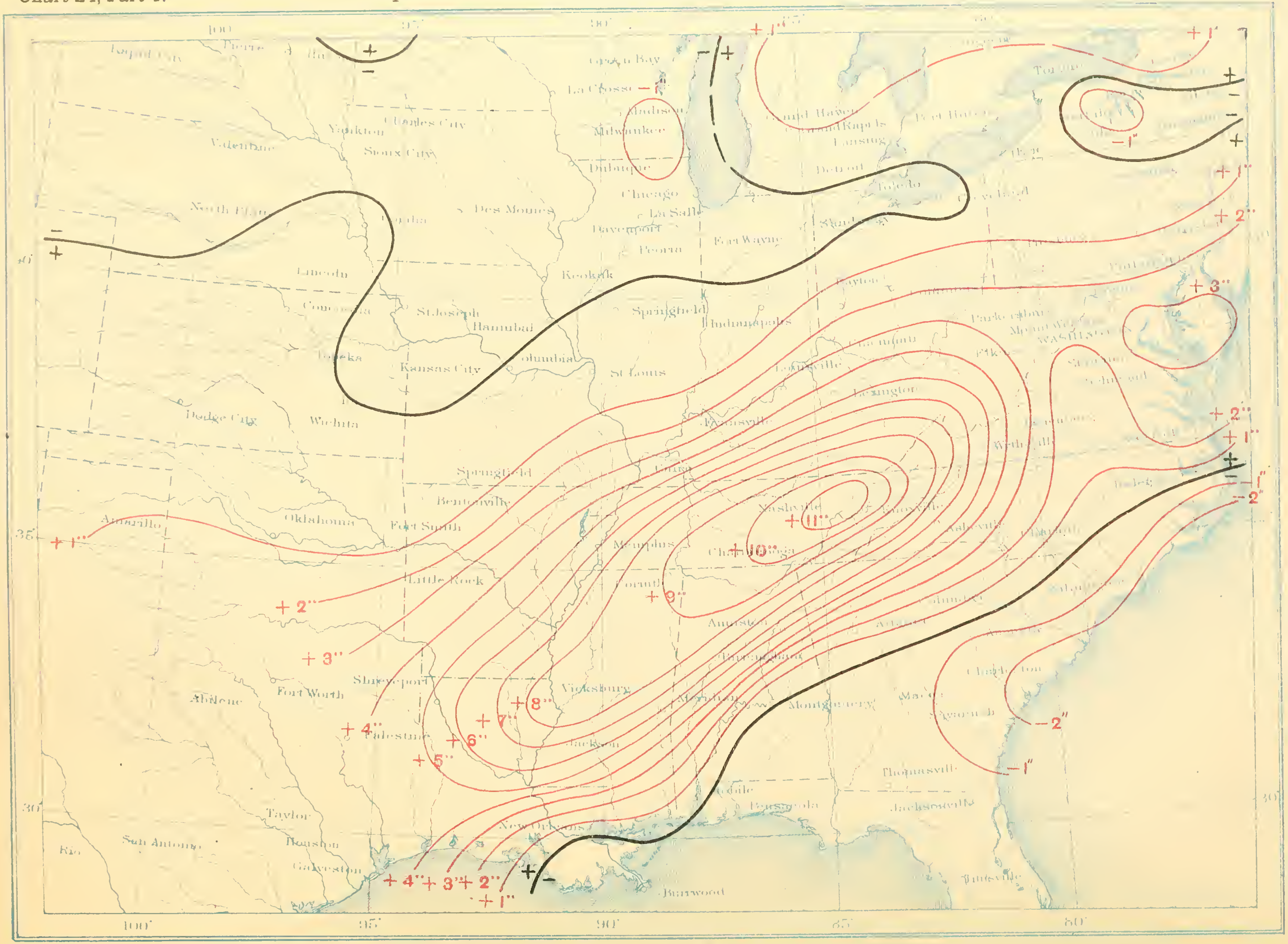


Chart 25, Part 1. Departure from normal precipitation, February, 1882 (inches).

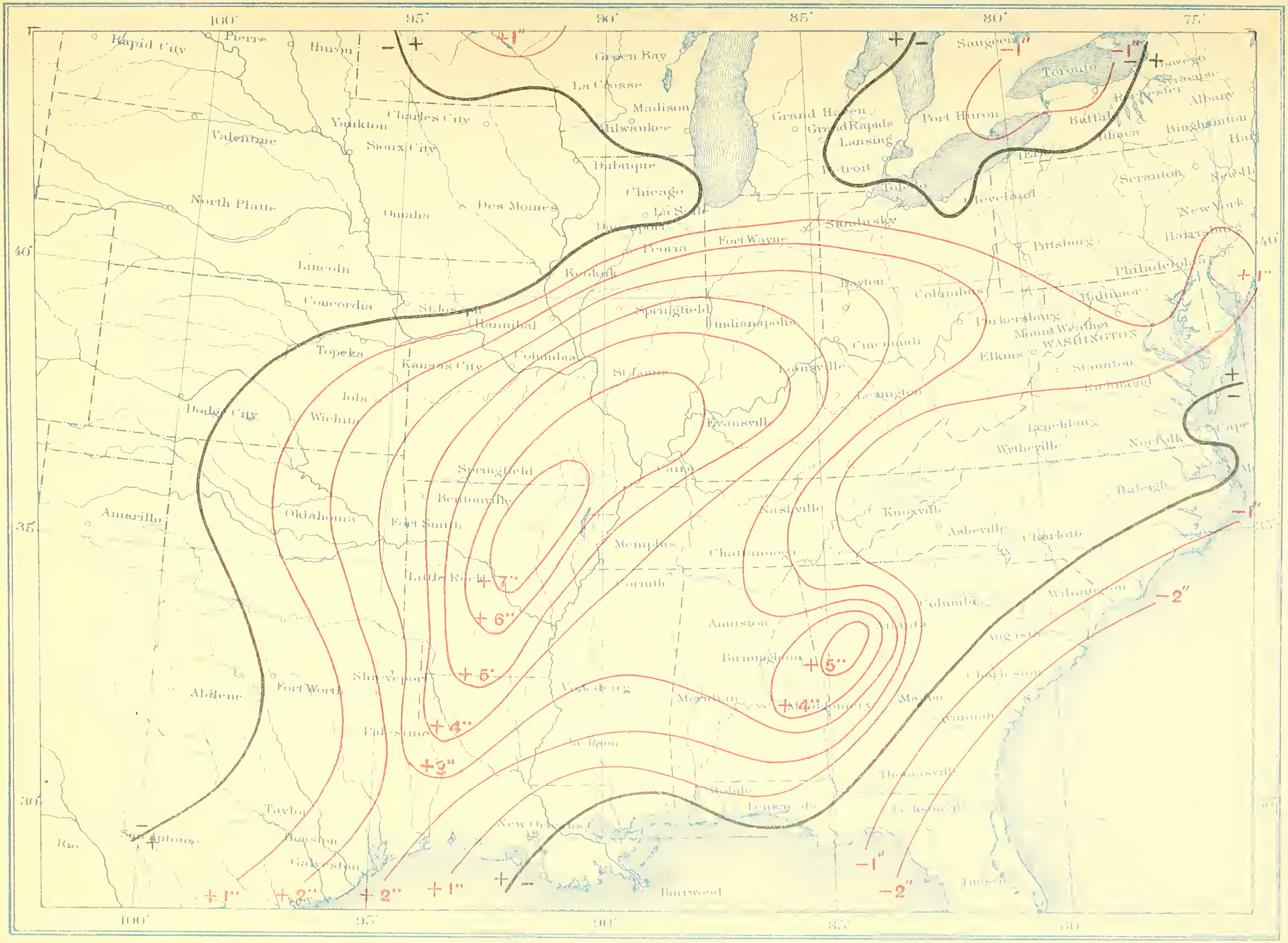
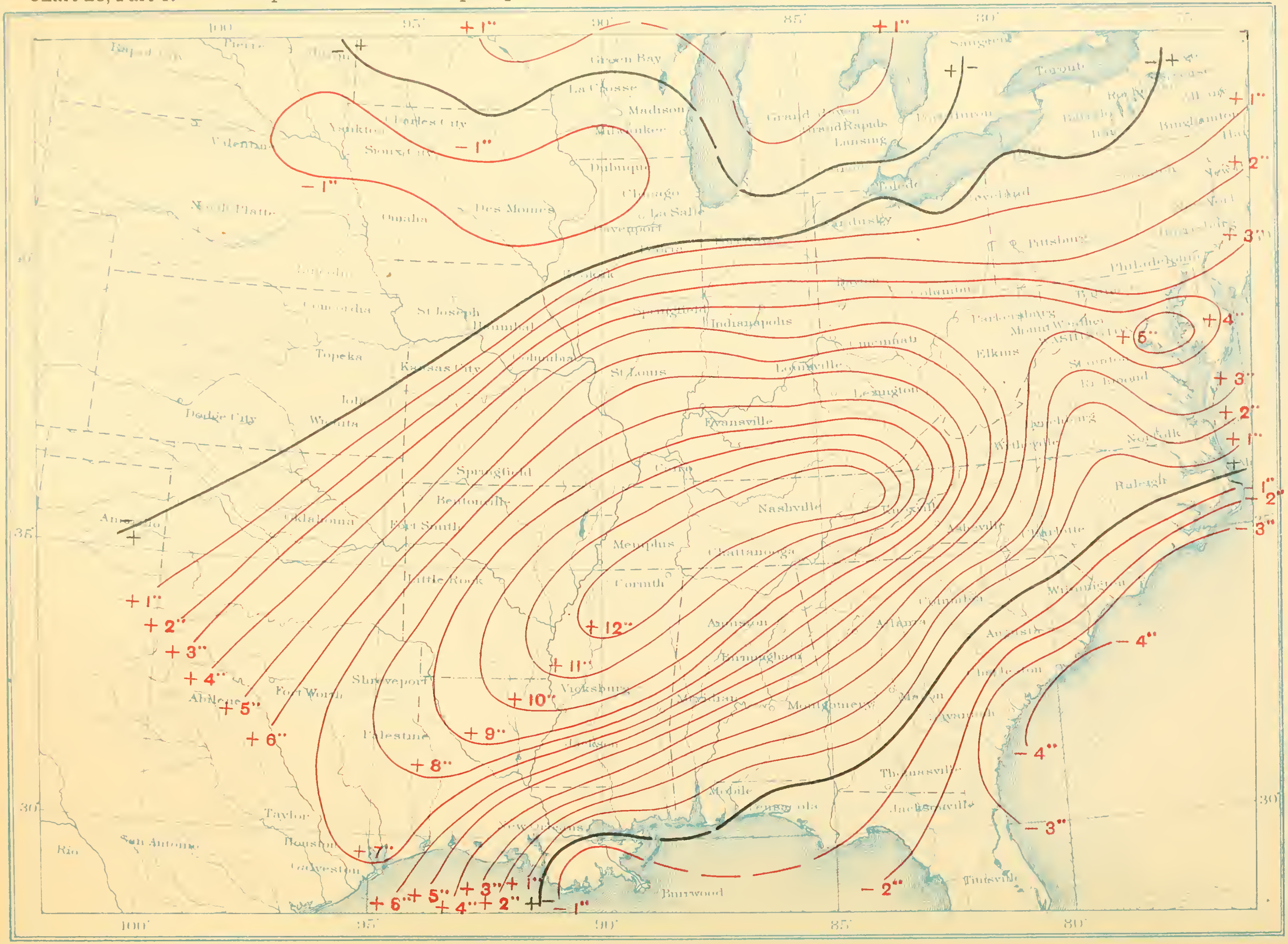


Chart 26, Part 1. Departure from normal precipitation, January 1 to February 28, inclusive, 1882 (inches).



Normal and actual precipitation, January, 1897 (inches).

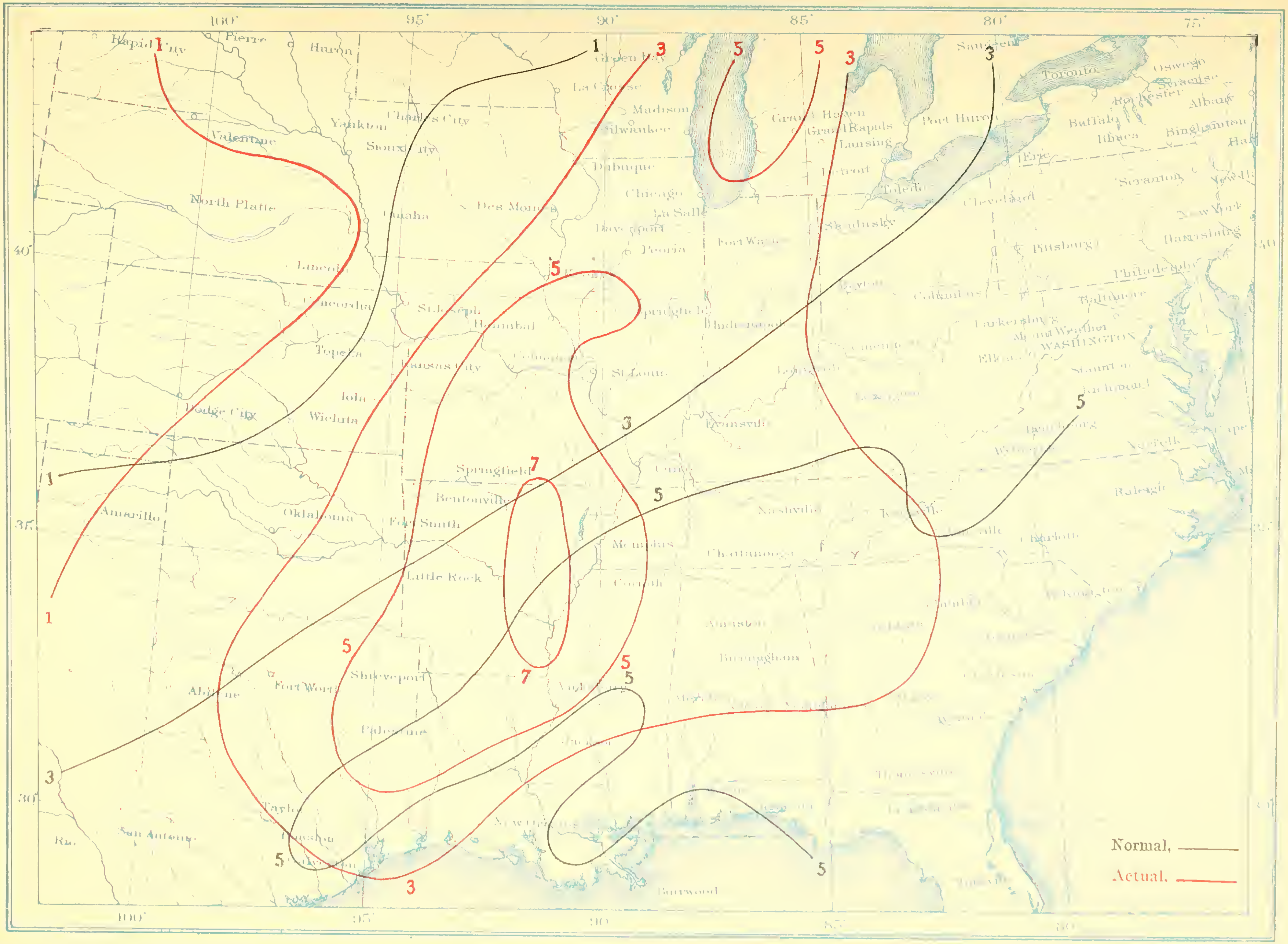


Chart 28, Part 1.

Normal and actual precipitation, February, 1897 (inches).

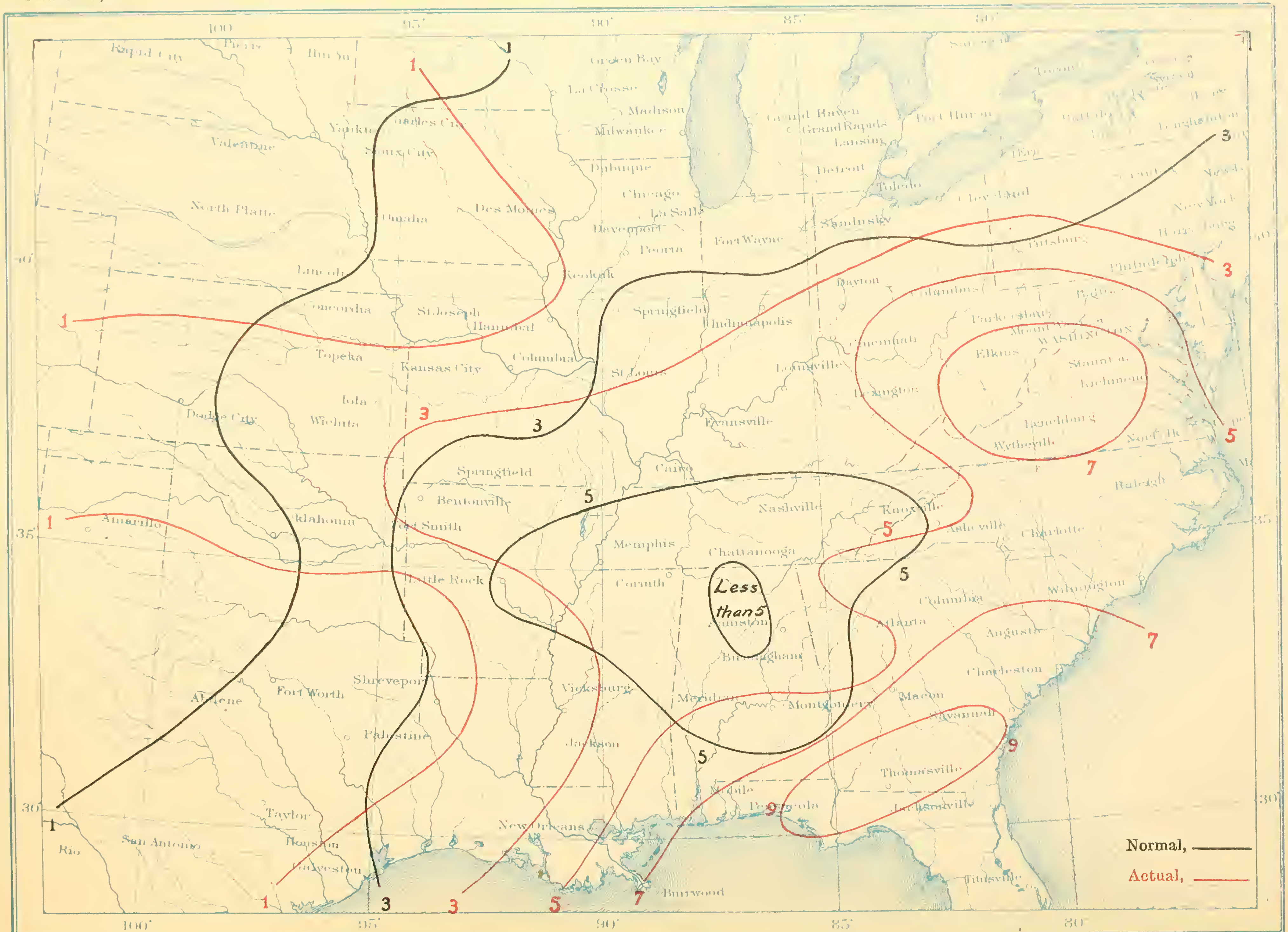
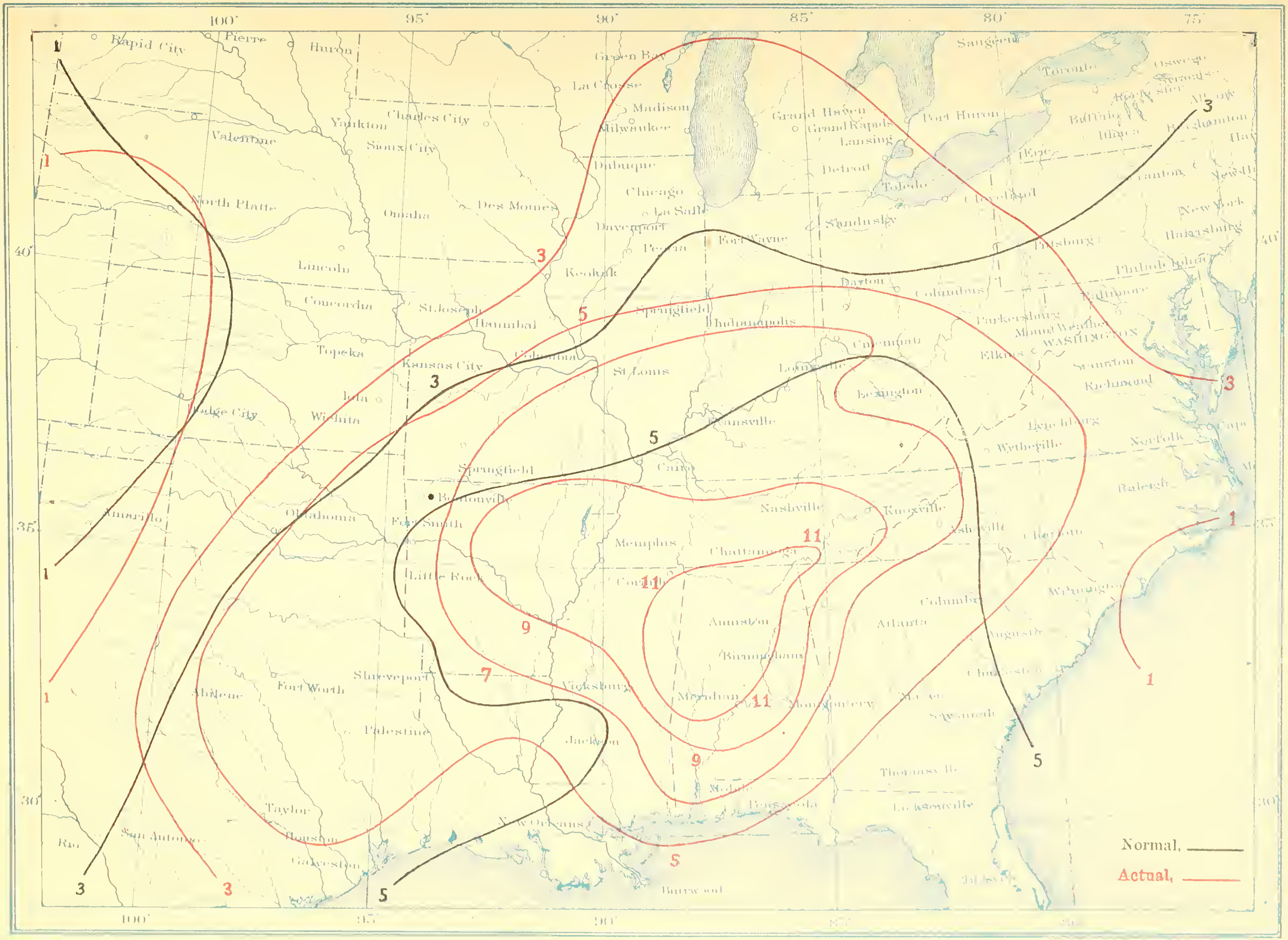


Chart 29, Part 1. Normal and actual precipitation, March, 1897 (inches).



Departure from normal precipitation, February, 1897 (inches).

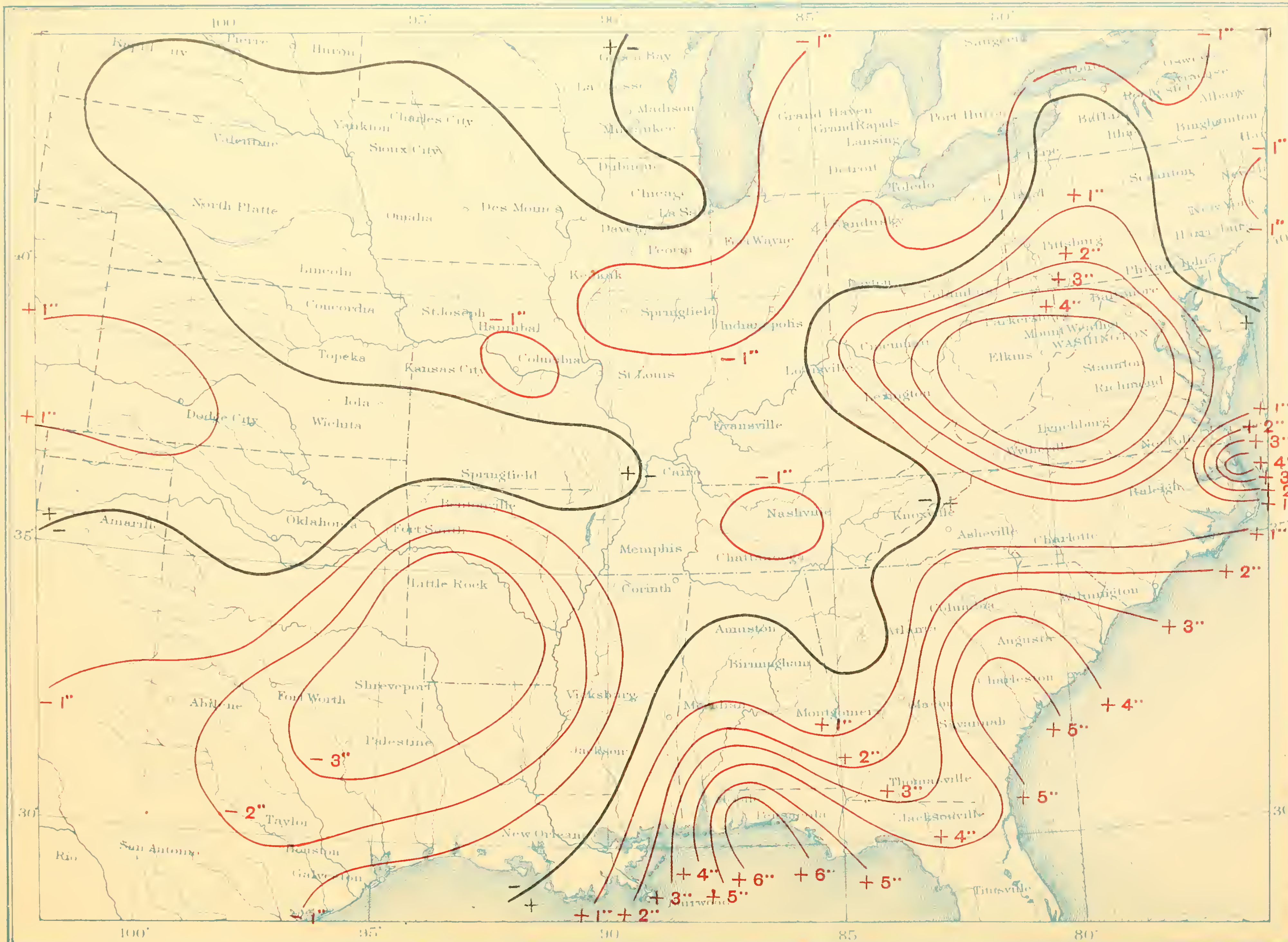


Chart 31, Part 1. Departure from normal precipitation, March, 1897 (inches).

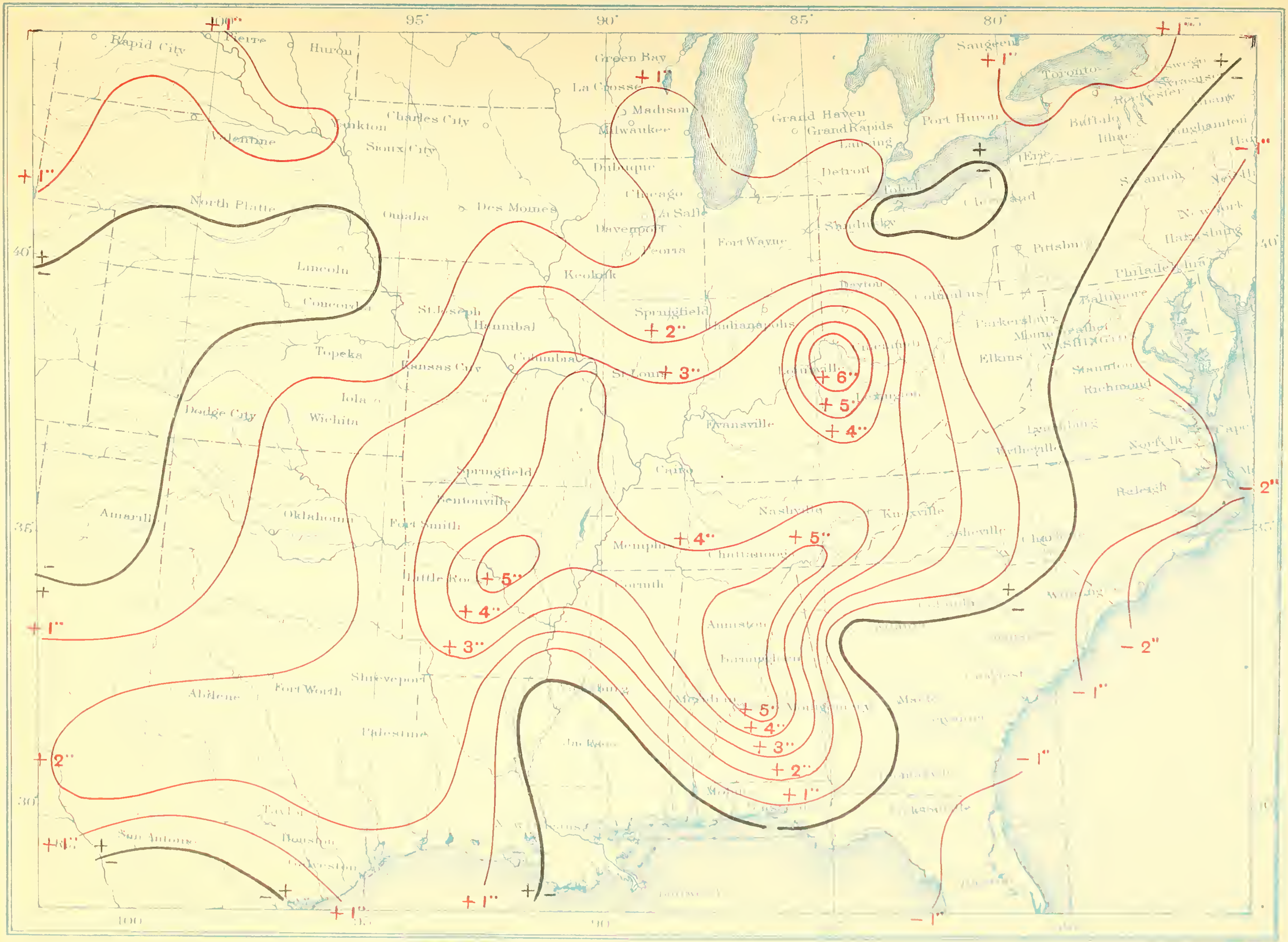


Chart 32, Part 1. Departure from normal precipitation, February 1 to March 31, inclusive, 1897 (inches).

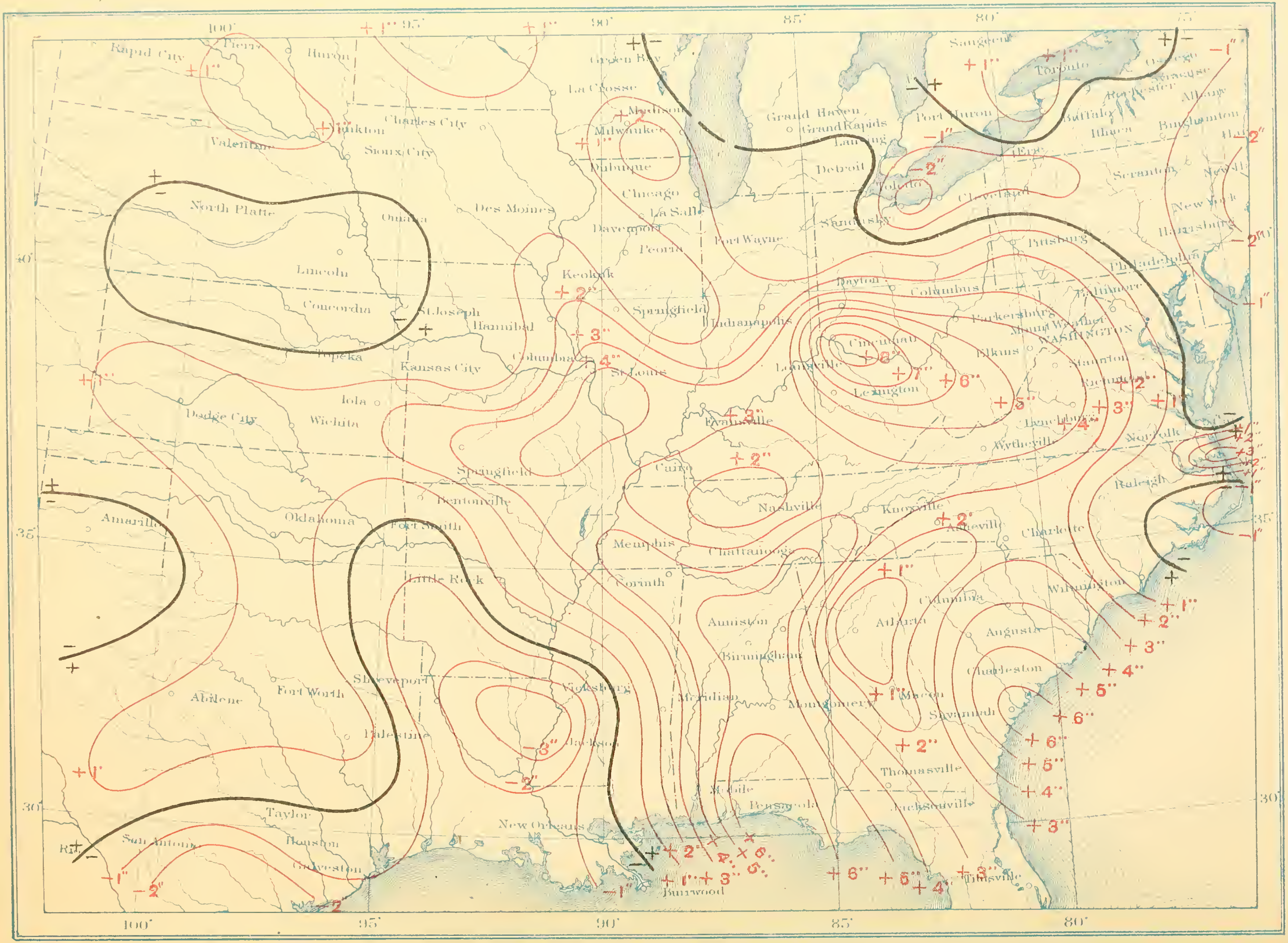


Chart 33, Part 1. Normal and actual precipitation, January, 1903 (inches).

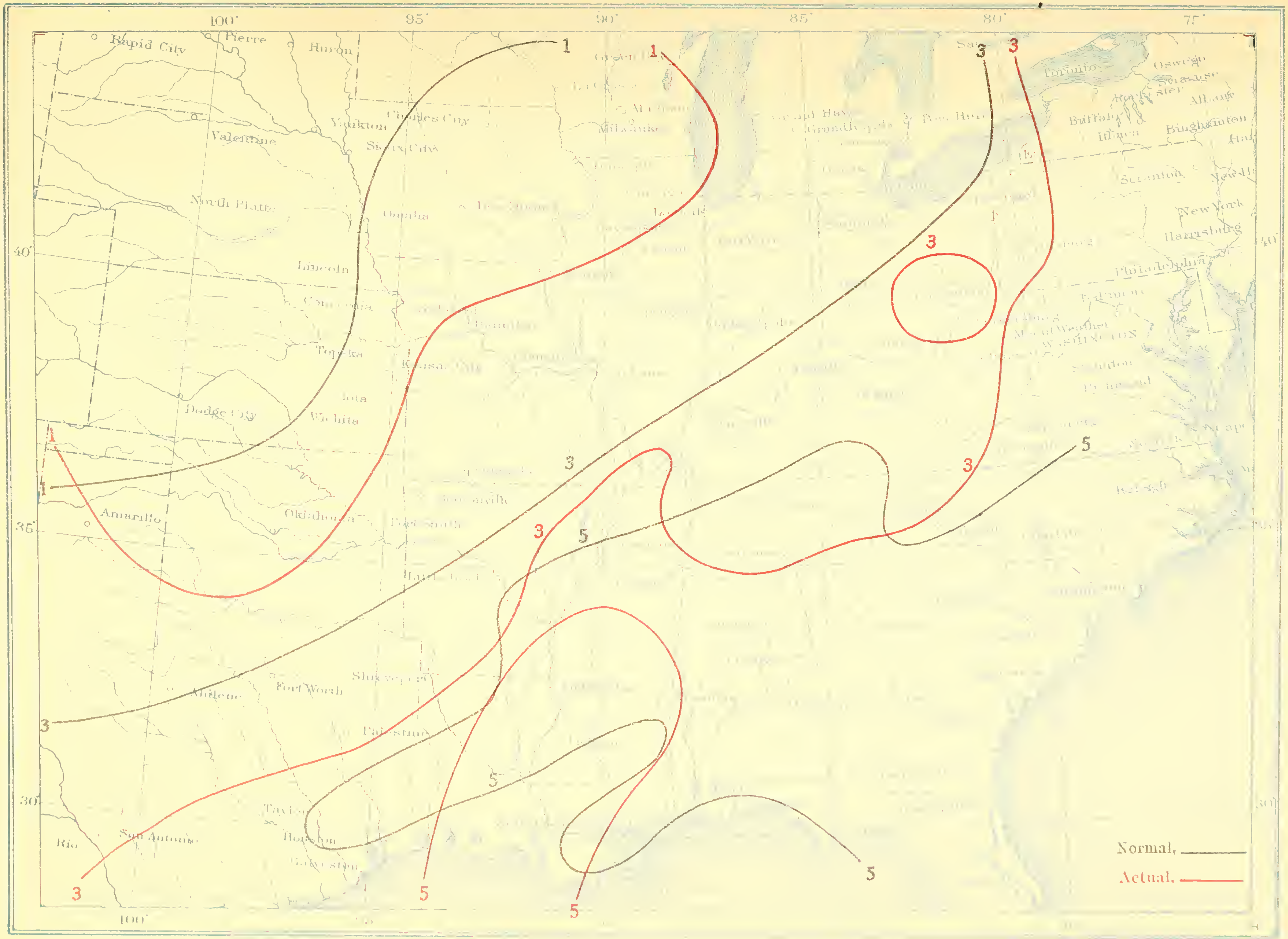
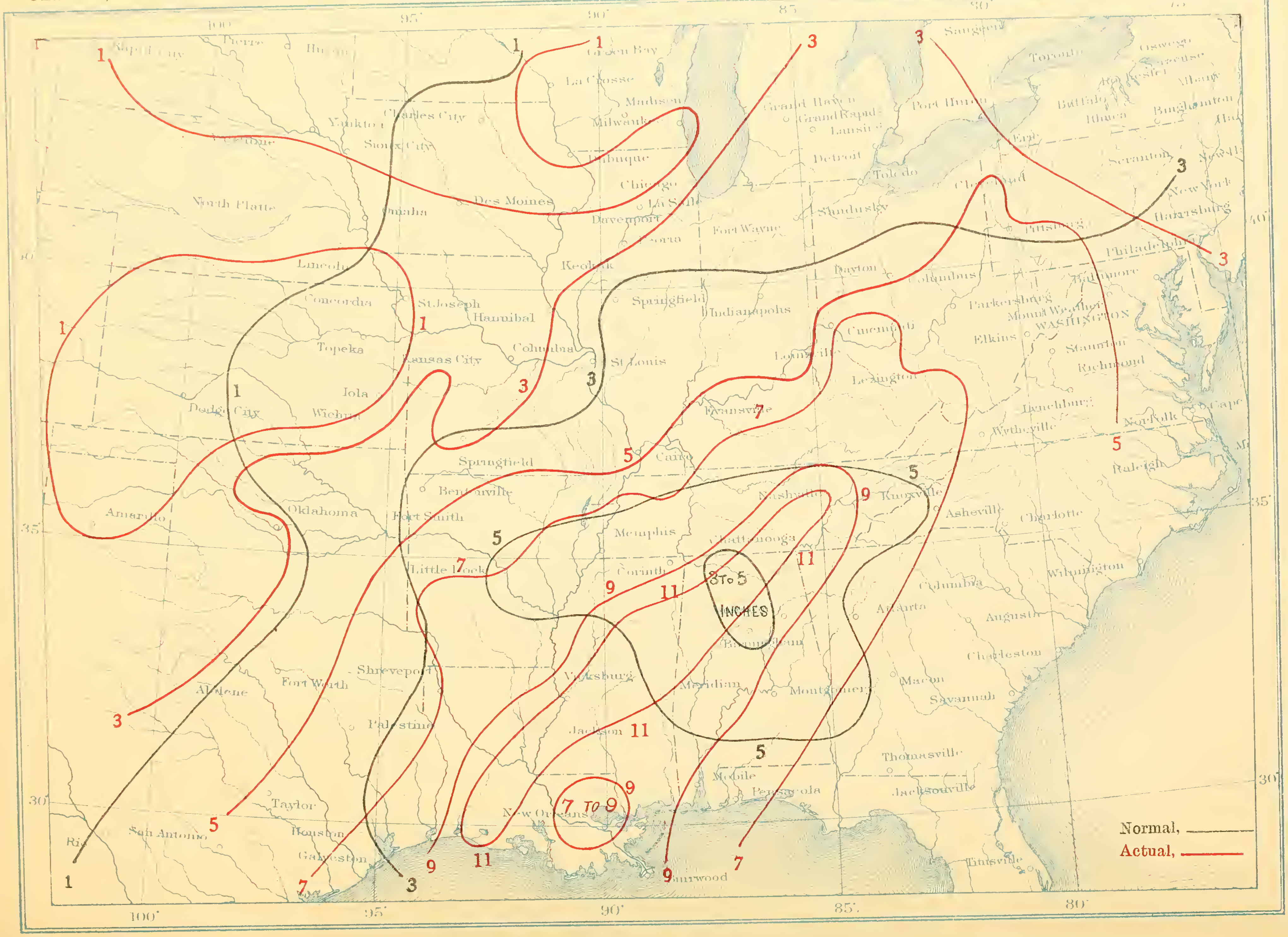


Chart 34, Part 1.

Normal and actual precipitation, February, 1903 (inches).



Normal and actual precipitation, March, 1903 (inches).

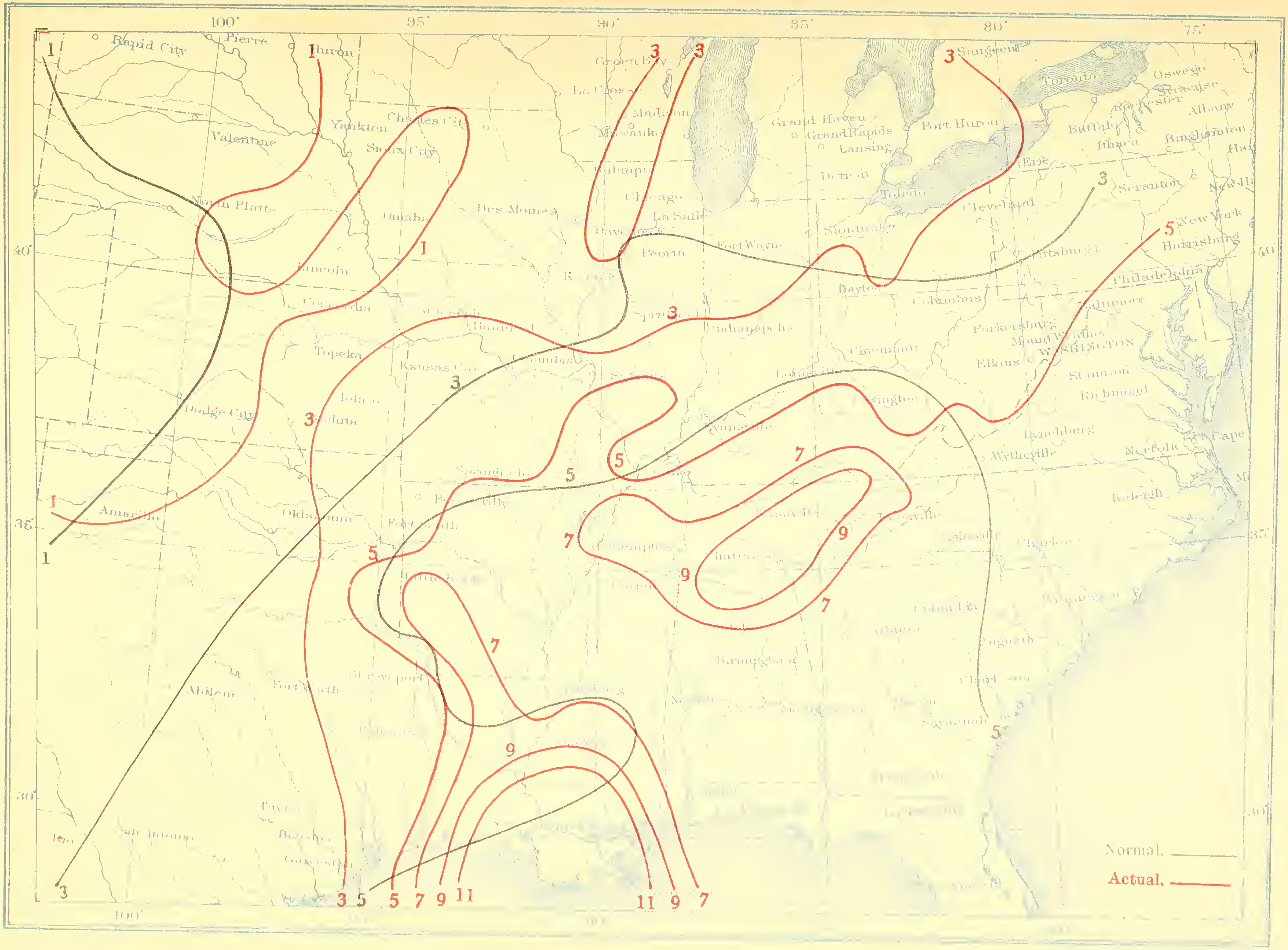


Diagram I, Part 1. Crest stages in the Mississippi River during floods of 1882, 1897, 1903, 1912, and 1913 (feet).

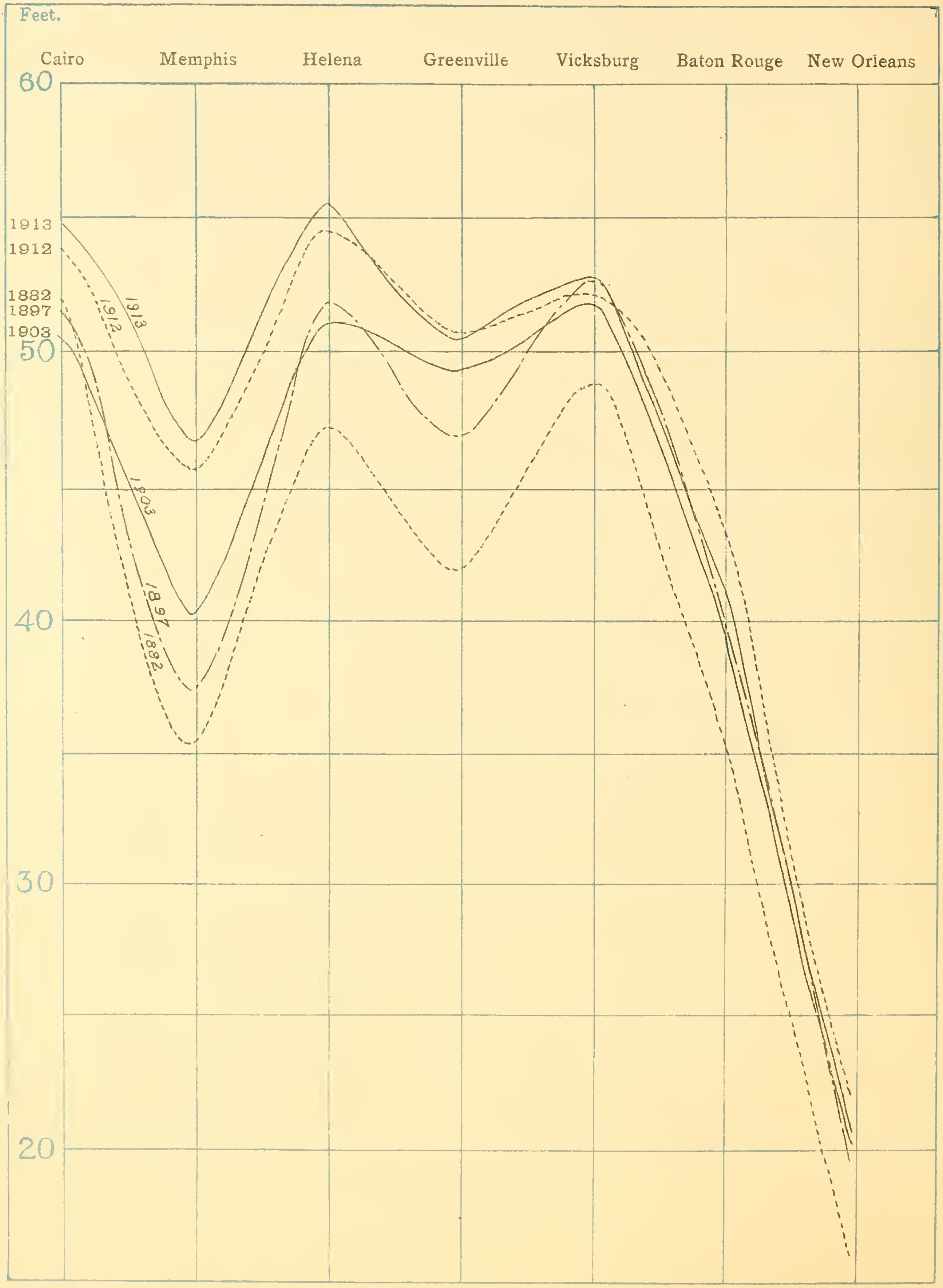


Diagram II, Part 1. Crest stages in principal tributaries during floods of 1882, 1897, 1903, 1912, and 1913 (feet).

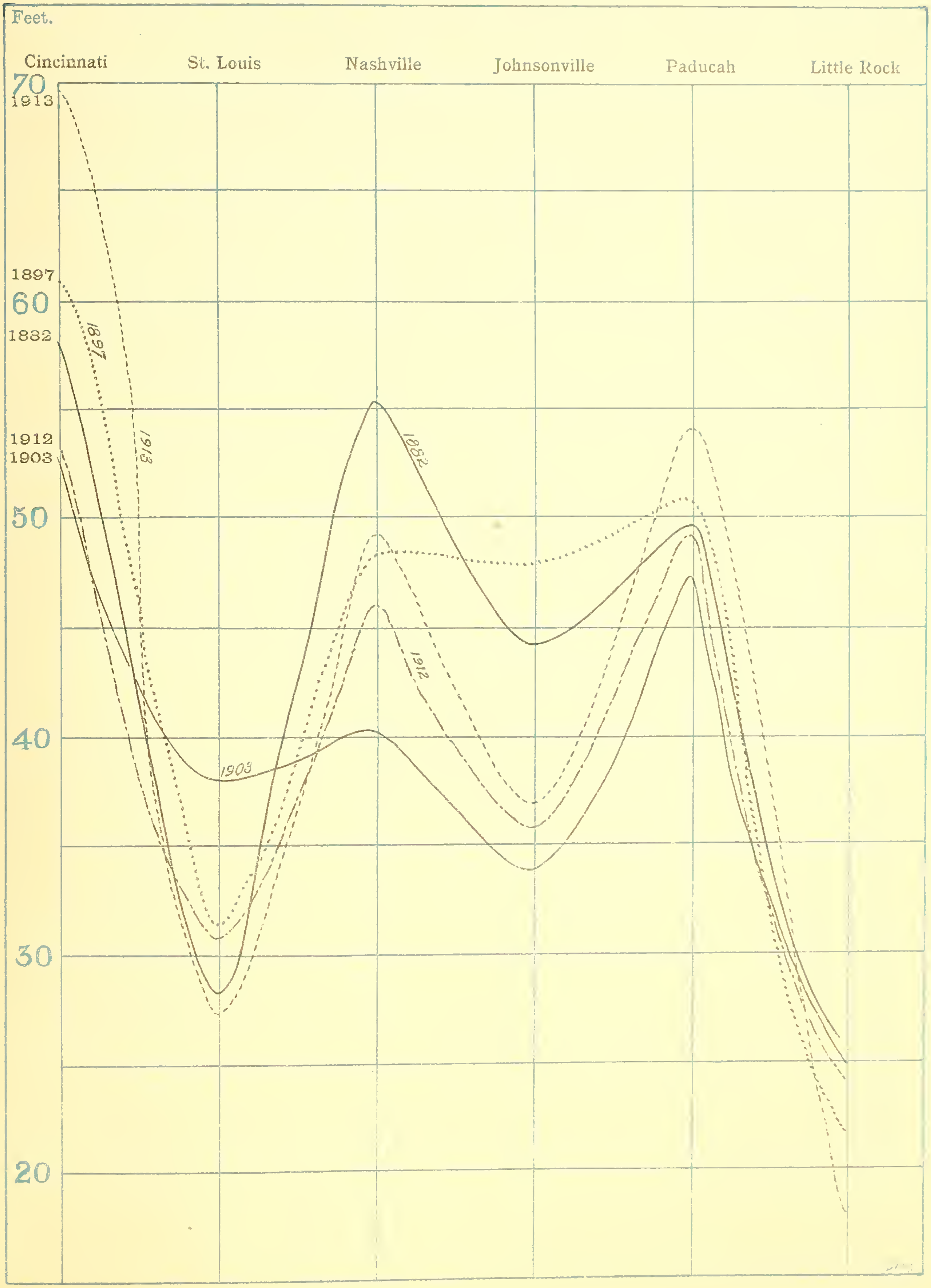


Diagram III, Part 1.

Hydrographs for floods of 1912 (feet).

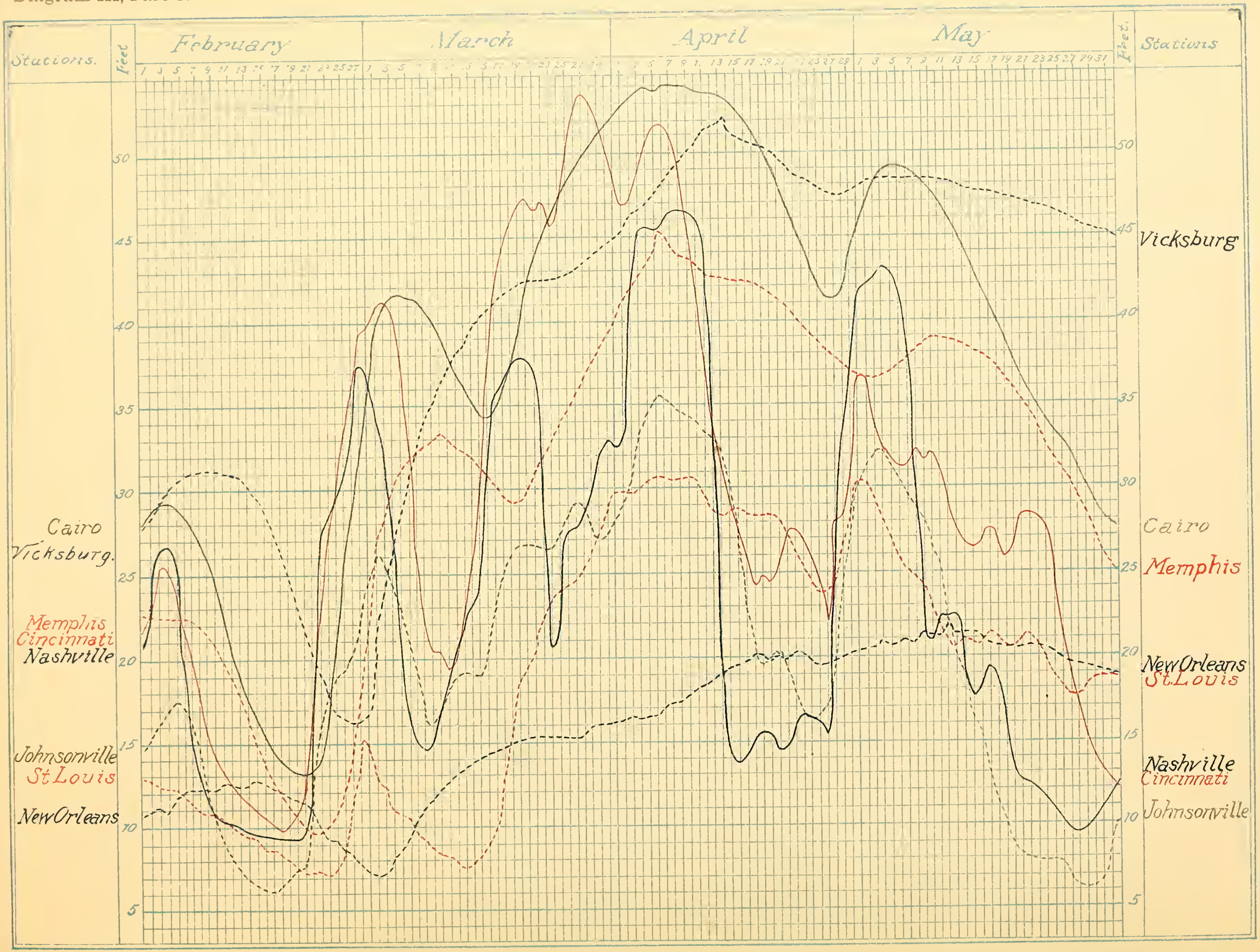


Diagram IV, Part 1.

Hydrographs for flood of 1882 (feet).

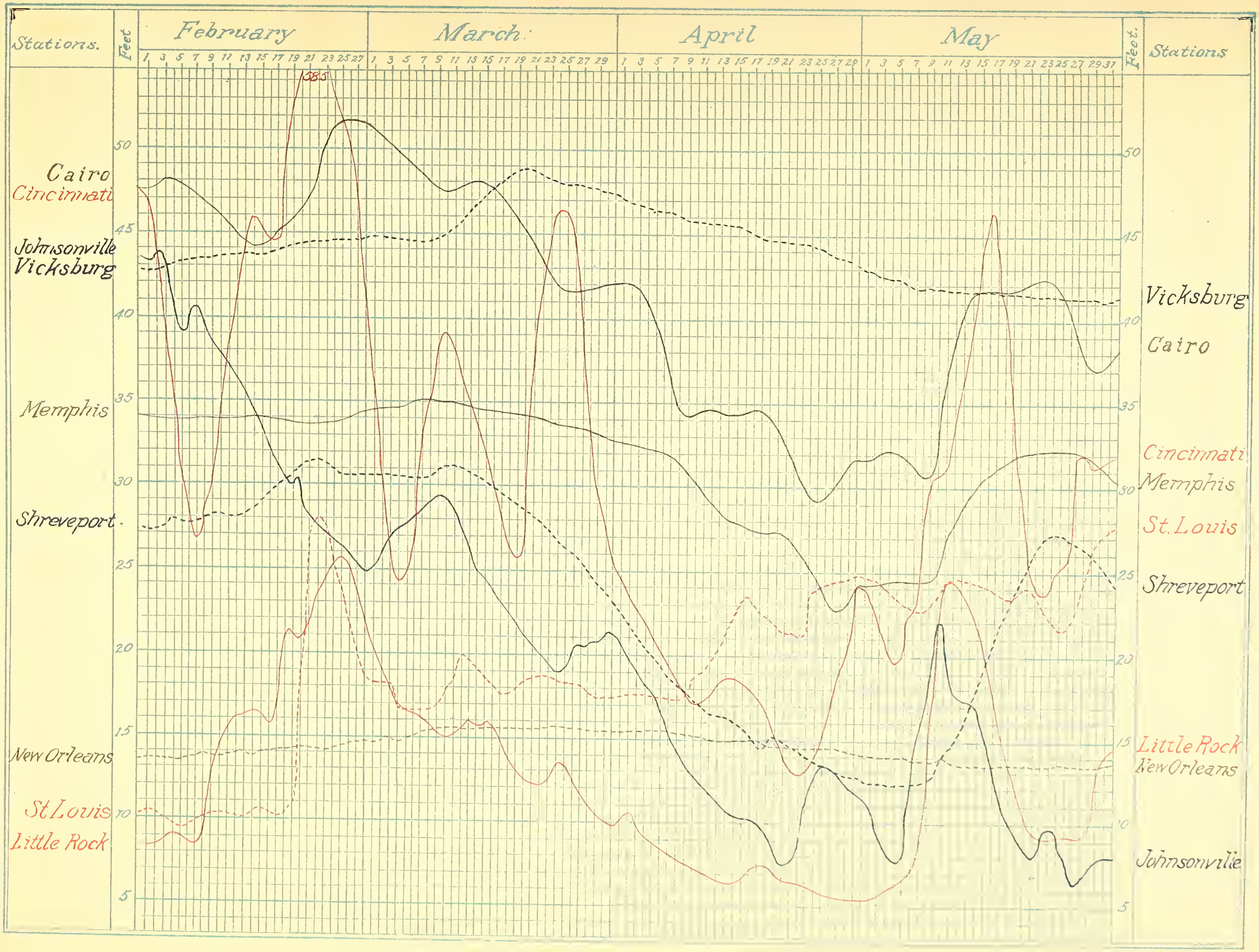


Diagram V, Part 1.

Hydrographs for flood of 1897 (feet).

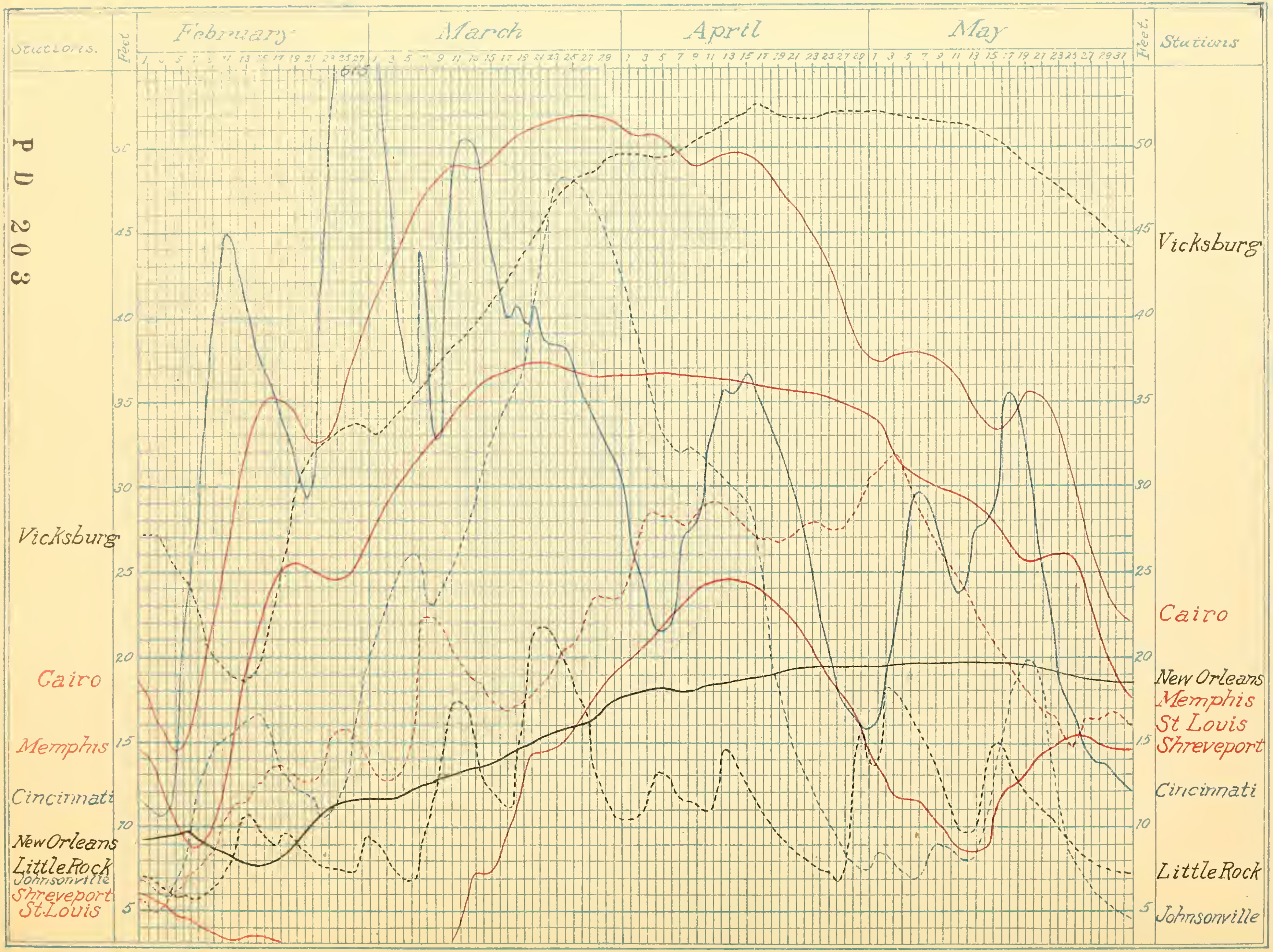


Diagram VI, Part 1.

Hydrographs for flood of 1903 (feet).

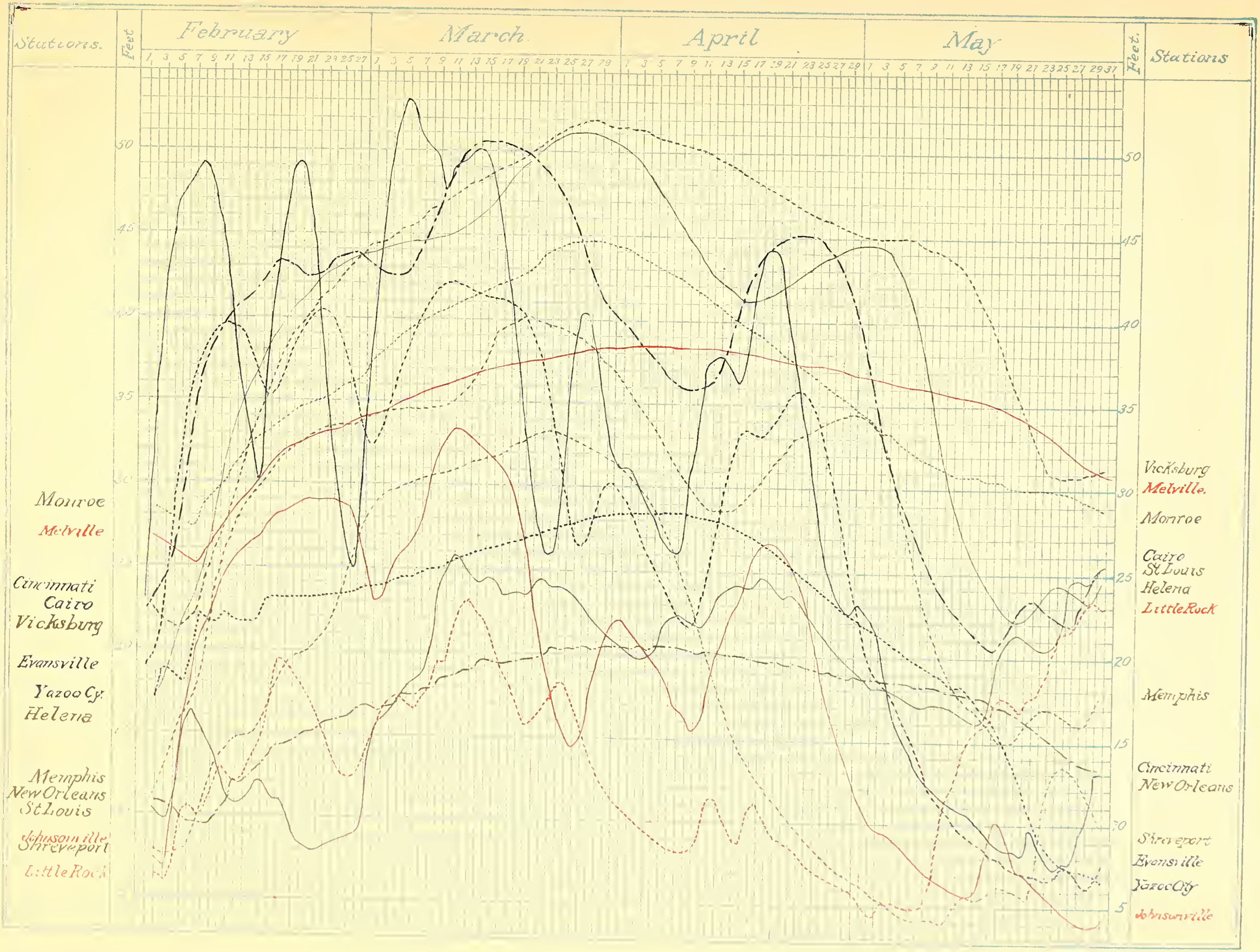


Diagram VII, Part 1. Hydrographs for floods of 1913 (feet). (Supplied by the author of Part II.)